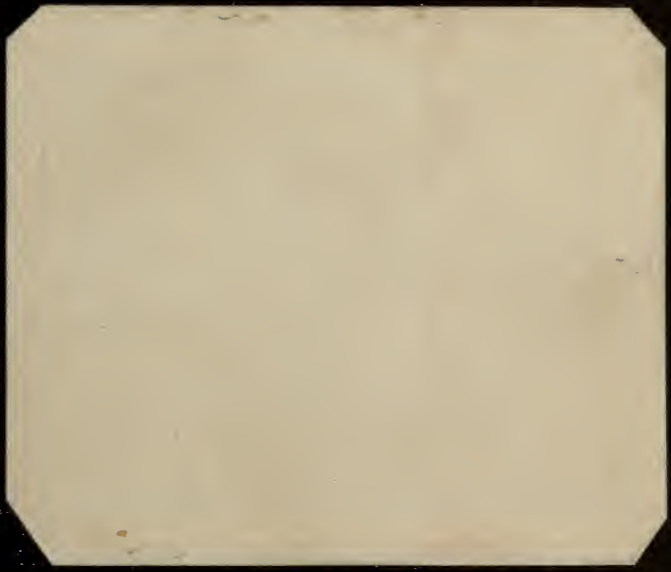


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COAL MINERS' SAFETY MANUAL

A Handbook for Miners

UNITED STATES DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, *Secretary*
U.S. BUREAU OF MINES
R. R. SAYERS, *Director*

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COAL MINERS' SAFETY MANUAL

A Handbook for Miners

By
J. J. FORBES, M. J. ANKENY
and FRANCIS FEEHAN

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COAL MINERS' SAFETY MANUAL [1]

By J. J. Forbes,[2] M. J. Ankeny,[3] and Francis Feehan [4]

INTRODUCTION

Reasonable safety rules and regulations and an effective safety organization are among the major requirements for the safe operation of coal mines. The application of safety rules and the effectiveness of any safety organization depend largely on the extent to which the rank and file of employees participate in the enforcement of these safety rules.

It is the moral and legal obligation of the operators of coal mines to provide safe mines in which to work and to regulate their operation so as to prevent fatalities and injuries. However, the men who work also are under obligation to prevent accidents. The various State mining laws place certain restrictions upon the conduct of the miners for their safety, and every miner knows that he, as well as the mine owner, can do far more than is required by law to help reduce the toll of accidents in mines.

The Appalachian agreement between the Bituminous-Coal Operators and the United Mine Workers of America, signed June 19, 1941, provides that "reasonable rules and regulations of the Operator for the protection of the persons of the Mine

[1] Work on manuscript completed March 16, 1942.
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[4] Mine safety commissioner.

Workers and the preservation of property shall be complied with." This agreement provides further:

> At each mine there shall be a Safety Committee. This committee shall be designated by the district president of the United Mine Workers of America, who shall also have authority to change its personnel. Its membership shall consist of a maximum of six Mine Workers, not less than 40 years of age and not less than 15 years' experience. No member of the Mine Committee shall be a member of the Safety Committee. The Safety Committee shall serve without compensation.
>
> This committee shall have the right to inspect any mine development or equipment used in producing coal for the purpose of observing its safe or unsafe condition when such questions are brought to its attention. If the committee believes conditions found are dangerous to life, it shall report its findings to management.

Here is an opportunity for mine workers to become a more vital force in the prevention of accidents in mines. The obligations imposed upon them by the provisions of this agreement not only call for initiative, tact, and reasonableness but also for certain familiarity with the technical aspects of accident prevention. It is believed, therefore, that the Bureau of Mines, with its wide store of information on safety, can be of substantial assistance. With this in view, it was suggested by the director of the Engineering Department of the United Mine Workers of America that the Bureau of Mines prepare a Coal Miners' Safety Manual for the information and use of the rank and file of mine workers and especially for the guidance of men selected to serve on Mine Safety Committees.

The information contained in the manual is based upon more than 30 years of field investigation and laboratory research by the Bureau of Mines and represents what mining engineers and coal-mine inspectors of the Bureau believe to be the minimum requirements for safety if coal mines are to be operated relatively free from accidents.

ACKNOWLEDGMENTS

Answers to the questions in this manual are based upon good safety practices developed in coal mining and in labora-

tory research and investigations of the Federal Bureau of Mines. Many of the questions and answers were taken directly from the Bureau's publications (Miners' Circular 40, Some Information on Timbering Bituminous-Coal Mines, and the 1940 edition of the Manual of First-Aid Instruction) and from the Mine Foreman's Guide, 1940, published by the West Virginia Department of Mines. The information in the Mine Foreman's Guide was in turn obtained from publications of Bureau of Mines and West Virginia School of Mines and official questions and answers in mine-foreman and fireboss examinations of various States. The authors of this publication, therefore, gratefully acknowledge the valuable information obtained from these publications in formulating this safety manual for coal miners. The authors also gratefully acknowledge the helpful advice and assistance given by Dr. Walter A. Polakov, Director of the Engineering Department of the United Mine Workers of America, who conceived the idea and suggested the preparation of a Coal Miners' Safety Manual; Dr. Polakov reviewed the manuscript, offering many constructive suggestions.

GENERAL SAFETY PROVISIONS

1. Q. *How many men were killed underground in bituminous-coal and anthracite mining in the typical years 1939 and 1940?*
   A. 1,014 men were killed in 1939 and 1,274 in 1940.
2. Q. *How many men were killed in bituminous-coal and anthracite mining during the 30-year period 1911 to 1940?*
   A. 59,492 miners were killed during the 30-year period.
3. Q. *What was the average number of men killed per year in bituminous-coal and anthracite mining during the 30-year period 1911 to 1940?*
   A. On the average 1,983 miners were killed each year.

4. Q. *How many bituminous-coal and anthracite miners, on the average, were employed for each miner killed each year?*
   A. An average of 1 of every 327 bituminous-coal and anthracite miners was killed each year during the 30-year period 1911 to 1940.
5. Q. *How can statistical information be obtained on coal-mine fatalities and injuries in the United States?*
   A. By writing to W. W. Adams, supervising statistician, Employment Statistics Section, Bureau of Mines, Washington, D. C.
6. Q. *Why were State and Federal mining laws enacted?*
   A. To insure the safety of persons employed within or at the mines and to protect mine property.
7. Q. *What is the minimum safe requirement as to access, from the interior of the mine, to escapeways to the surface?*
   A. A safe roadway should be provided to at least two outlets.
8. Q. *How should the direction to outlets or escapeways be marked?*
   A. By signboards, placed conspicuously throughout the mine.
9. Q. *Who should be in charge when men are working on any shift, whether the mine is idle or working?*
   A. A certified foreman.
10. Q. *When should a mine-foreman or fireboss certificate be revoked?*
    A. When the holder of such certificate violates or ignores any of the provisions of the mining laws.
11. Q. *Who is responsible for acts of the assistant foreman?*
    A. The mine foreman.
12. Q. *How often should unsealed entrances to old workings be traveled and examined?*
    A. Regularly; at least once every shift.
13. Q. *How often should airways be traveled and examined?*
    A. Once every week.

14. Q. *By whom should an official be accompanied when exploring abandoned workings not regularly inspected at least once each week?*
    A. By at least one other person.
15. Q. *What should be done before employees are permitted to enter idle or abandoned sections?*
    A. The sections should be examined by a certified official.
16. Q. *What instrument should be carried by an official exploring abandoned workings?*
    A. A permissible flame safety lamp.
17. Q. *What type of lights should not be carried by officials exploring abandoned workings?*
    A. Open lights.
18. Q. *What should be done at entrances to dangerous places in a mine?*
    A. Entrances to dangerous places should be fenced off.
19. Q. *What should be done when dangers are reported?*
    A. Such dangers should be removed promptly and a danger sign kept posted until the dangerous condition has been remedied.
20. Q. *When it is impracticable to remedy a dangerous condition, what should be done?*
    A. Every person whose safety is menaced should be notified and removed to a place of safety.
21. Q. *What supplies should be available at all times for proper maintenance of the mine?*
    A. Enough to permit every miner to work in safety.
22. Q. *Under what conditions should an employee be prohibited from entering a mine on idle days to perform work?*
    A. When official inspection and supervision are not provided.
23. Q. *When may persons, other than certified officials, pass across danger boards?*
    A. When accompanied by a certified official to assist in making a dangerous place safe.
24. Q. *When should a certified official pass across danger boards?*

A. Only in the performance of his duties relative to the removal of the hazard for which the danger board was erected.

25. Q. *What qualifications should mine officials have relative to flame safety lamps?*
A. They should be competent to assemble, test, and use flame safety lamps.

26. Q. *Why is it necessary to have safety rules for the guidance of mine employees?*
A. They call attention to hazards and indicate ways to avoid accidents.

27. Q. *How does the enforcement of safety rules prevent accidents?*
A. By preventing persons from performing acts known to be hazardous.

28. Q. *Why should employees offer suggestions relative to safety rules?*
A. Because safety concerns them and their families and because they may be more familiar with the conditions of their working places than the officials are.

29. Q. *Why should safety rules be enforced?*
A. To help prevent killing and maiming men.

30. Q. *How should the employees be advised of the rules and regulations of the mine?*
A. By printed booklets and notices posted on conspicuous bulletin boards.

31. Q. *What benefits can be obtained from safety meetings?*
A. They offer a medium for the exchange of ideas and experiences and provide means for a more thorough safety education.

32. Q. *What is the duty of the mine foreman relative to new employees?*
A. To instruct each new employee as to the particular dangers incident to his work.

33. Q. *How is an inexperienced person required to work until he is familiar with the dangers incident to his work?*
A. Under the immediate direction of a mine foreman or other experienced worker.
34. Q. *How should men entering and leaving mines be regulated?*
A. By a system for checking men in and out.
35. Q. *After an injury what should be done before the injured person is moved?*
A. First-aid treatment should be given.
36. Q. *Why should all injuries, even those of a trivial nature, be reported?*
A. Serious consequences from infection may result from even trivial injuries.
37. Q. *Should conditions at the scene of a fatal accident be altered?*
A. Conditions should be left unchanged until an investigation has been made.
38. Q. *What first-aid equipment should be provided at a mine?*
A. For each 50 men or less, one stretcher, one woolen and one waterproof blanket, and all necessary first-aid material.
39. Q. *How near to working places should first-aid material be kept?*
A. Adequate first-aid material, including blankets and stretchers, should be kept in each working section.
40. Q. *What should be worn as head and foot protection?*
A. Safety hats and safety shoes.
41. Q. *What protection should be provided for the eyes when men are grinding, cutting, welding, or striking where particles may fly?*
A. Goggles.
42. Q. *What safety device should be worn by men working in or around shafts or other deep excavations?*
A. Safety belts.

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43. Q. *How should illuminating and signal lights be maintained?*
A. In perfect operating condition.
44. Q. *What materials should never be permitted to accumulate in structures in and about mines?*
A. Oil, grease, and rubbish. (*See* fig. 1.)
45. Q. *What protective devices should be provided for openings in floors or ground?*
A. Guardrails or covers.
46. Q. *What protective devices should be provided for steps, landings, and platforms?*
A. Hand railings.
47. Q. *What should never be permitted on steps, landings, and platforms?*
A. Oil, grease, rubbish, ice, and snow.
48. Q. *What may be the result of wide rooms and standing narrow pillars?*
A. Effective ventilation may be difficult, and squeezes or creeps may occur.
49. Q. *What may be the result of an irregular pillar line?*
A. Pillars not pulled in proper sequence make extraction difficult and dangerous.
50. Q. *Why should pillars be extracted in proper sequence?*
A. To obtain good falls and prevent excessive weight on the standing pillars.
51. Q. *Why should good falls be obtained on a pillar line?*
A. To relieve the pillar from the extra weight caused by overhanging strata and thus permit its safe extraction.
52. Q. *Why should ample pillars be left along haulageways?*
A. To protect from possible squeezes or creeps.
53. Q. *What is a squeeze?*
A. The action of excessive weight upon pillars not strong enough to support that weight.

FIGURE 1.—Oil fires can be prevented by storing the oil in clean, fireproof storage houses equipped with steel doors.

54. Q. *What is a creep?*
A. The action of an excessive weight upon a weak floor or roof, causing the floor to heave or the roof to sag.
55. Q. *How can a squeeze be avoided?*
A. By providing strong enough pillars and obtaining adequate falls by thorough and systematic mining.
56. Q. *How can a creep be stopped?*
A. By rapid extraction of pillars to obtain a break and by leaving pillars strong enough to protect adjoining sections.
57. Q. *What is a bump?*
A. A bump is the result of the sudden breaking of a strong overhanging roof and the snapping back in position of the strata over the coal when the tension is released.

PREVENTION OF ACCIDENTS FROM FALLS OF ROOF AND COAL

TYPICAL EXAMPLES OF ACCIDENTS FROM FALLS OF ROOF AND COAL

1. A miner was loading coal in a place that had been standing for some time. Two timbers had been set on each side before work was begun. The miner had loaded out the top of a middle cut but had not set any additional posts. As he was drilling a hole in the bottom bench a slip broke loose, tripped the post supporting one end, and fell upon him causing his death.

Safety posts should have been set as the coal was removed.

2. A mine employee was walking along a haulageway when he was suddenly struck by a fall of slate that caused his death.

The loose slate along the haulageway should have been discovered and taken down or securely timbered before it fell. (See fig. 2.)

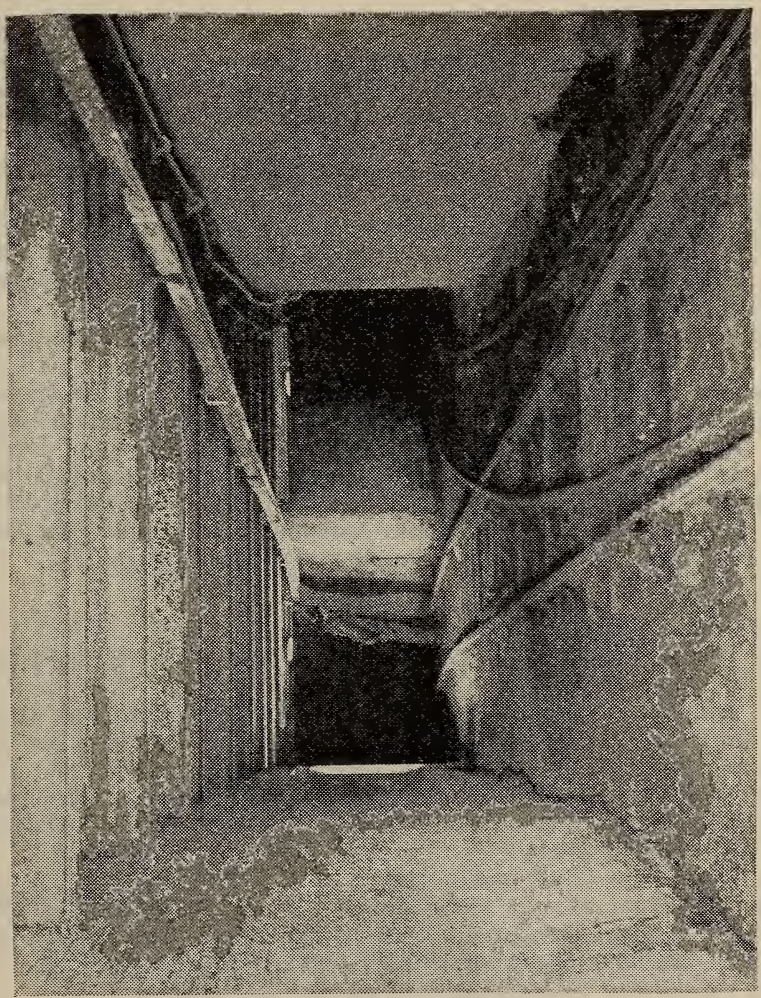

FIGURE 2.—Adequate precautions will prevent accidents from falls along haulage roads.

3. A miner was working in a pillar place with the left side open to the gob. No safety posts had been set, and the nearest road post was 8 feet from the face. The miner's body was found under a large piece of rock that had fallen between the track and the open side of the place.

This miner was killed because his working place was not timbered properly.

4. A fall of slate had blocked the track just outby the cars at a loading face. A laborer came to clean up the fall. He began to work without examining the top and was caught under a second fall.

He died because he failed to examine the roof before beginning work.

5. A new haulageway was being constructed, and it was necessary to slab one rib. Several posts had been removed so that a cut could be made, but one post that supported some loose slate was left standing. A miner knocked out this post with a hammer and was caught and killed under the resulting fall.

The loose slate should have been supported by a cross bar, or a post puller should have been used to remove the post.

QUESTIONS AND ANSWERS

1. Q. *What is the cause of most fatalities and injuries in coal mines?*
   A. Statistics gathered by the Bureau of Mines indicate that more coal miners are killed or injured by falls of roof and coal than by any other cause.
2. Q. *How many underground coal miners were killed by falls of roof and coal in the United States in 2 recent typical years?*
   A. 621 in 1939 and 614 in 1940.
3. Q. *What percentage of the total number of deaths of underground coal miners killed in 1939 and in 1940 was due to falls of roof and coal?*
   A. 61 percent in 1939 and 48 percent in 1940.

4. Q. *How many fatalities and injuries are caused by falls of roof in a typical year, such as 1939?*
   A. 516 fatal and 8,236 nonfatal injuries.
5. Q. *How many fatalities and injuries are caused by falls of face or rib in a typical year, such as 1939?*
   A. 84 fatal and 4,657 nonfatal injuries.
6. Q. *How many fatalities and injuries are caused by rush of coal, rock, or gob in a typical year, such as 1939?*
   A. 15 fatal and 421 nonfatal injuries.
7. Q. *How many fatalities and injuries are caused by roof falls due to car or machine knocking out timber in a typical year, such as 1939?*
   A. 6 fatal and 421 nonfatal injuries.
8. Q. *How do injuries from falls of roof and coal occur?*
   A. The roof or coal becomes weakened and falls upon the victim, sometimes with little or no warning.
9. Q. *How can falls of roof and coal be prevented?*
   A. By taking down all loose and dangerous material or by securing it properly with timbers.

INSPECTION AND TESTING OF ROOF AND COAL

10. Q. *How can loose and dangerous material be detected?*
    A. By careful inspection and testing.
11. Q. *Who is primarily responsible for inspection and testing of roof in a mine?*
    A. The mine foreman, his assistants, and the firebosses.
12. Q. *Does a miner have any responsibility in the inspection and testing of the roof, ribs, and face?*
    A. Yes. For his own safety and protection he should be constantly familiar with the condition of the roof, ribs, and face in his working place.
13. Q. *How can you determine whether the roof is solid or loose and needs additional support?*
    A. Roof generally is tested by sounding—striking it with a bar and noting the character of the sound. If the

sound is hollow or "drummy" it indicates loose and probably dangerous roof that should be taken down promptly or supported with timbers.

14. Q. *How can the condition of the roof, ribs, and face be ascertained?*
    A. By visual inspection, sounding, and the vibration method of testing.
15. Q. *Should a miner examine the timber or posts in his working place and, if so, how?*
    A. Yes, by visual inspection to see that none of the timbers are broken, and by striking them a sharp blow with a pick or testing tool to see that they are tight.
16. Q. *When should a mine foreman, his assistants, or the firebosses test the roof, ribs, face, and timbers in a working place?*
    A. Whenever the working place is visited.
17. Q. *When should the miner or loader test the roof, ribs, face, and timbers in his working place?*
    A. Upon entering the place at the beginning of the shift, and at least every hour thereafter—oftener, if the roof is suspected of becoming dangerous.
18. Q. *What other mine employees should test the roof, sides, face, and timbers in working places?*
    A. Shot firers, timbermen, trackmen, mining-machine operators, loading-machine operators, drillers, and all others who have occasion to work at the face.
19. Q. *How may roof areas away from the face regions be safeguarded?*
    A. By constant vigilance of mine officials and firebosses and by prompt attention to any dangers that may develop.
20. Q. *Has a miner or face worker any responsibility in connection with the condition of the roof areas away from his working place?*
    A. Yes; he should report promptly to his foreman any unsafe conditions observed.

21. Q. *When dangerous roof is discovered in the mine, what steps should be taken?*
A. Dangerous roof should be taken down immediately or secured by timbers or posts.
22. Q. *What type of tool should be used for testing mine roof?*
A. A testing bar should be of a material that is a non-conductor of electricity, such as wood or fiber. It may have a metal cap and ferrule, as wood soon frays and becomes less effective. The cap should be rounded and have no sharp edges. The bar should balance above the center, preferably about one-third of the length of the bar from the cap. The heavier the bar, within reasonable limits, the better it is for testing. The diameter should be 1 to 1½ inches and the length 2 to 5 feet or more to conform to the height of the coal bed.
23. Q. *Should roof in mines be sounded systematically, particularly at the face?*
A. Some roof may sound solid when tested and fall soon afterward as a result of hidden slips or other unseen dangers; therefore, the safest precaution is to sound the roof at frequent and regular intervals.
24. Q. *Is sounding roof always reliable?*
A. Sounding roof is not always reliable. A dangerous piece of roof, especially if large, often does not give a "drummy" or hollow sound that the ear can detect.
25. Q. *What is a more reliable method of testing roof?*
A. A more reliable method is to place the bare fingers of one hand lightly against the roof and, with the other hand, to strike the roof lightly with a testing bar. If the roof does not appear to be loose it should be struck a quick, sharp blow. A slow, heavy blow does not cause proper vibration. The amount or degree of vibration of the roof against the fingers

indicates the condition of the roof. In excavations more than 8 feet high the test should be made from a special scaffold or horse. Do not stand under the piece of roof being tested. Miners should test the roof frequently throughout the shift. (*See* fig. 3.)

PREVENTING FALLS OF ROOF AND COAL

26. Q. *What are some of the hidden dangers of mine roof?*
    A. The roof may have slip planes or cracks, "kettle bottoms," or fossil stumps, inverted "horsebacks," and clay veins. The presence of slip planes and fossil stumps often is concealed by a thin layer of coal. Slip planes or cracks in the roof may cause a large part of the roof to fall immediately after the coal has been blasted or while the coal is being loaded.
27. Q. *What should a miner do to protect himself from these hidden dangers?*
    A. The safest precaution is to suspect and treat all roof as dangerous and always set enough timber to support the roof properly or give warning of approaching danger.
28. Q. *What should be done in a place where the roof is in a dangerous condition?*
    A. A foreman should be called, and he should remain in the place until it is made safe or the men withdrawn and the place dangered off.
29. Q. *What must be done if foremen do not remedy the dangerous condition?*
    A. It must be reported in writing to the management.
30. Q. *What should each employee do before he begins work?*
    A. He should examine thoroughly the roof and general condition and set the timbers necessary to make the place safe.

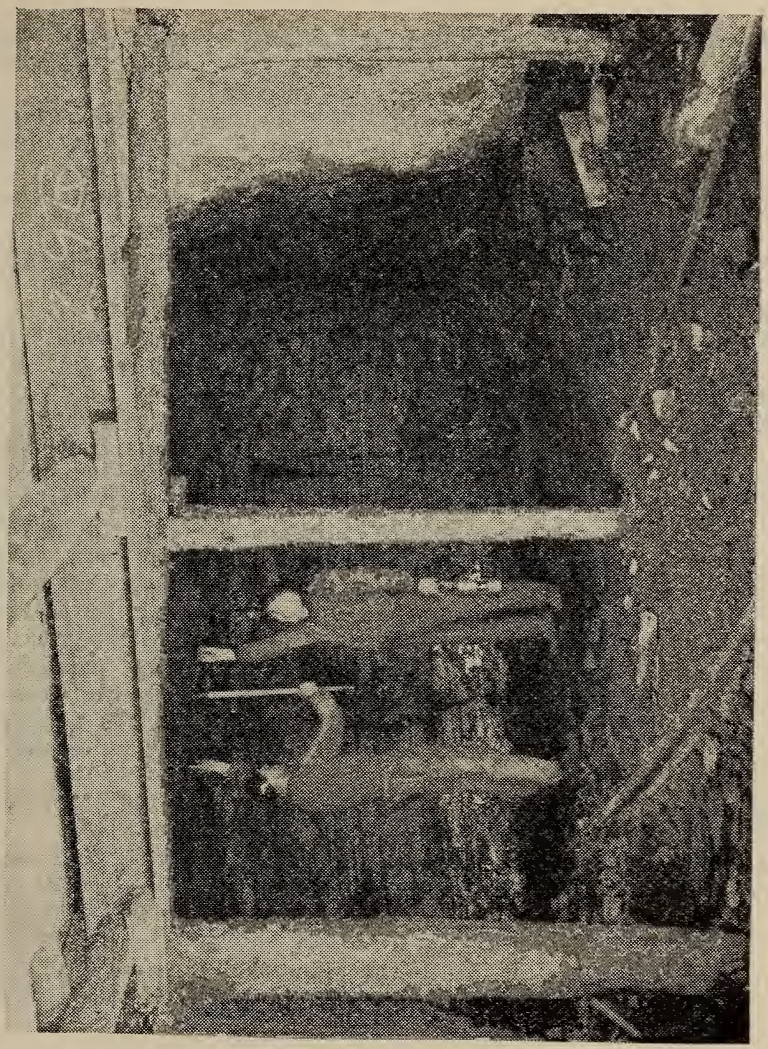

FIGURE 3.—The vibration method should be employed for testing roof, and the roof should be tested often so that dangerous roof will be discovered before it falls.

31. Q. *In addition to permanent roof support, how should machinemen protect themselves from falls of roof while making a cut?*
    A. Frequent examinations should be made, and safety posts should be set as required. Posts that are removed should be reset promptly.
32. Q. *In what part of a coal mine do most accidents from falls occur?*
    A. Approximately 85 percent of all accidents from falls occur at or near the working face.
33. Q. *Are these accidents all due to falls of roof?*
    A. Most of them result from falls of roof, but some are from falls of coal from the sides or from the face.
34. Q. *Why is coal often left up for a roof?*
    A. In some mines where the coal is 6 feet or more thick and where the immediate roof material above the coal bed falls easily when exposed to the air, it is often the practice to leave 1 foot or more of the coal against the roof. This can be done where the coal bed has a natural bedding plane or parting a suitable distance from the roof; it can be done, also, by using top-cutting machines. Coal usually makes a good roof where it has not been shattered by blasting, but it should be supported by props or timber wherever it shows signs of becoming loose; in working places the roof should always be supported by props or timber, even though it appears to be solid.
35. Q. *How do accidents occur from falls of coal off the sides and face?*
    A. Some coal, especially when undercut, is likely to loosen and roll out into the opening, or slabs may fall off the face or ribs. These falls are especially dangerous in beds more than 10 feet thick. There is much danger in falls from the sides and faces of pitching beds. When the coal along the sides or ribs is left

hanging overhead it is called a brow, and if not supported by timber it is likely to fall and cause an accident; therefore, all brows of coal or roof material should be pulled down by a bar, blasted down, or suitably supported by timbers. There is also danger of rock sliding off the gob in pillar workings where the protecting fenders of coal are broken or are too thin.

36. Q. *How may men at the face be protected?*
A. A good practice is to use sprags—short props set into a hitch in the floor and into a recess or hitch in the coal at intervals across the face of the place (entry, room, pillar, or longwall). Where the coal is undercut by hand the sprags may be short props set under the coal and wedged securely against the floor.

37. Q. *Do the roof and coal in parts of the mine where pillars are being removed present more danger than in the solid or first mining, and if so, why?*
A. When pillars are removed, not only the immediate roof but the main roof material and the overlying strata begin to move, and this movement may cause the immediate roof to break and fall. If the main roof begins to move the coal pillars may be partly crushed, and slabs of the coal are likely to fall from them. In extracting pillars, therefore, miners have to contend with the action of the main roof. A system of timbering used in solid work will not always meet the requirements in pillar work. In pillaring, props are set closer, cross bars and sprags may become necessary (in some instances cribs must be used), and frequent testing of the roof is most essential.

TIMBERING SYSTEMS

38. Q. *In planning defense against accidents from falls, what is the first important step?*
    A. The adoption of a program of timbering that calls for a concerted effort to reduce the accidents from falls of roof and coal. (*See* fig. 4.)
39. Q. *Who is responsible for the adoption of a timbering plan?*
    A. The mine operator or the superintendents and foremen representing him.
40. Q. *What are some of the essential steps in formulating a program for the use of timber to prevent accidents from falls of roof and coal?*
    A. 1. The nature of the roof and its tendency to fall when not supported by timbers should be studied carefully.
    2. Detailed information should be collected as to the circumstances under which persons have been injured or killed by falls of roof or coal.
    3. A committee of miners employed at the mine should be appointed, and their suggestions and advice should be weighed carefully.
    4. State and Federal mine inspectors should be consulted.
    5. After careful consideration of the information obtained, a definite system of timbering should be adopted that calls for placing props, cross bars, and timber sets at intervals adapted to the conditions found in the mine, with provision for additional timbering where conditions are more dangerous than usual.
    6. When a system has been adopted, faithful adherence to it is necessary if the full benefit is to be realized.

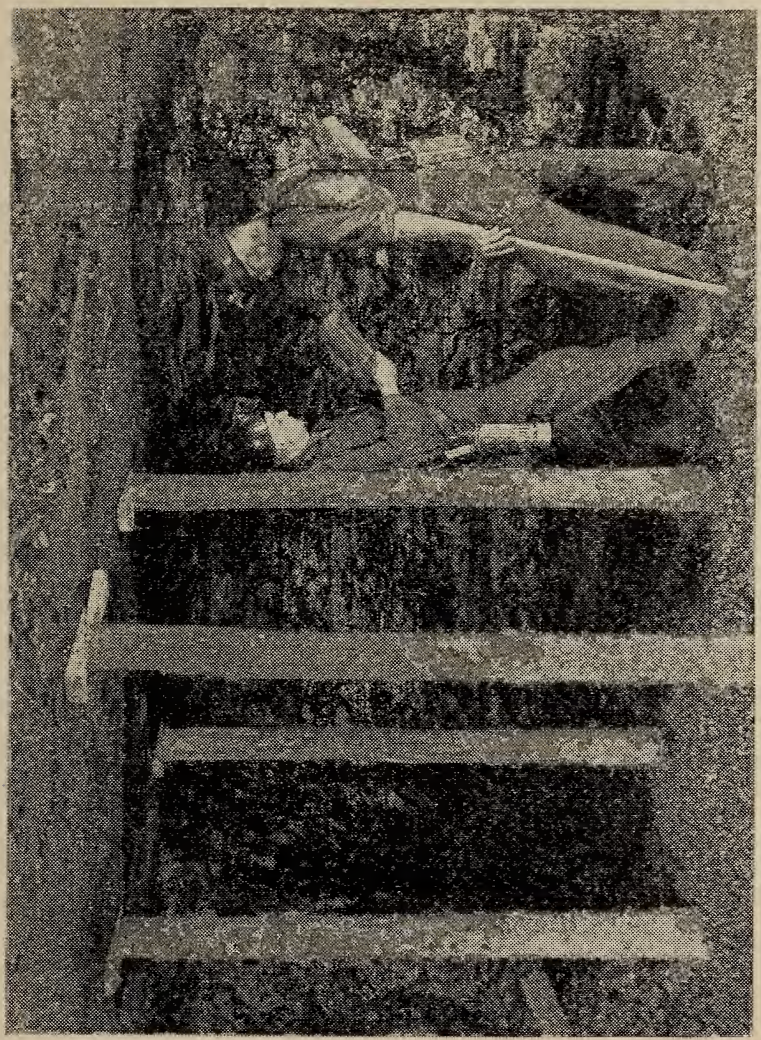

FIGURE 4.—A definite timbering plan should be adopted; miners should be made thoroughly familiar with it and should follow it carefully.

41. Q. *What procedure is best for carrying out the system of timbering adopted?*
A. Close supervision and instructions to the employees, regular inspection, and active cooperation of the miners are essential to the success of any system of timbering.

ACTION OF ROOF

42. Q. *What causes roof to fall in coal mines?*
A. Removal of coal leaves exposed roof strata as well as the remaining coal unsupported. If the roof or coal is weak and cannot support its own weight or later becomes weakened it will fall unless supported.
43. Q. *How does the roof act when the coal is removed?*
A. The roof may be considered a beam or plate of rock or coal that will bend and break according to the laws of mechanics.
44. Q. *Does the roof generally break without warning?*
A. No; like a beam, it tends to bend, with the greatest bending about midway between the coal ribs or other supports.
45. Q. *Can the bending be retarded by timbering?*
A. Yes; usually, if the roof is timbered promptly with suitable timber it can be supported.
46. Q. *How does the roof act when timbered?*
A. Posts with softwood cap pieces allow the roof to settle slightly, compressing the cap pieces, which act as cushions. The various layers or strata of rock settle, arch, and form a new consolidated mass in the overlying strata, retarding the effect of the weight of the roof.
47. Q. *Do abnormal stresses generally occur where roof is about to fall, and, if so, how can they be detected?*
A. Generally the invisible bending or other movement sets up stresses that are detected by cracking sounds given off as the roof is broken, and often small

chips or pieces of roof material fall from the roof. A sudden increase in these warning signs should be investigated, and means of protecting the workmen should be used without delay.

48. Q. *What is roof called where gas pressures cause falls?*
A. It is generally called "snap" roof.

49. Q. *Is gas ever present in the bottom strata?*
A. Yes; gas frequently is present in the bottom strata and occasionally causes the bottom to heave. In several mines pressure has been so great that the gas has burst from the bottom and caused crevices to form.

50. Q *Where do most falls of roof occur?*
A. Naturally, falls are most likely to occur where roof is freshly exposed; consequently, the greatest number do occur at or relatively close to the face; 85 to 87 percent of falls occur in the face region.

TIMBERING METHODS

51. Q. *Why must the roof of a mine be supported by timber?*
A. Roof timbering serves two main purposes—it supports the immediate roof and gives warning of heavy roof and approaching squeezes or falls.

52. Q. *How much of the roof material should the timber hold in place?*
A. The timber should hold in place roof material ranging in thickness from a few inches to 4 or 5 feet, consisting of the immediate roof of the mine. It would be impracticable and ordinarily impossible to use enough timber to support all the material from the roof to the surface. Mine timbers ordinarily are designed or expected to withstand 50 pounds to 3 tons pressure per square foot of bearing area.

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53. Q. *When is the proper time to timber?*
A. As soon as possible after excavating. It is unwise to wait for the roof to sag or take weight, and it is very important to support it with timber before the roof rock has a chance to become loose.

54. Q. *What is the material of the roof; that is, what rock forms the roof?*
A. The roof material may be fireclay, shale, draw slate, bone, sandstone, limestone, or a layer of the coal itself.

55. Q. *What is the material in the floor or pavement?*
A. Floor or pavement may consist of any of the materials that form the roof, but most frequently it is fireclay.

56. Q. *What is the immediate roof of a mine?*
A. The immediate roof lies directly against the coal; it may be a single layer or a series of layers of rock material a few inches to 5 or 6 feet thick and usually requires timbering to support it when the coal is removed. The falling of this material causes many accidents in mines; its nature and thickness determine how it may be supported by timbers or taken down when it becomes dangerous.

57. Q. *What is the main roof of a mine?*
A. The main roof lies above the immediate roof and may range in thickness from a few feet to several hundred. It is massive and seldom falls, except in parts of the mine where the coal has been taken out over a relatively large area, such as in pillar regions or in longwall mining. The main roof, therefore, must be given attention and care where pillars are removed or in longwall mining. Ordinary timbers used to support the immediate roof have little effect in supporting the main roof. However, timber placed in the form of batteries, cogs, or cribs will aid in controlling the main roof or cause

it to break along a predetermined line, as where pillars are being drawn or in longwall mining. The only known method of partly holding the main roof consists in filling the excavated space with rock, sand, or earthy material, but no amount of timber will entirely prevent movement of the main roof.

58. Q. *What are the problems of roof support that demand attention within a mine?*

A. Roof support requires more or less constant attention in three main parts of the mine: (1) Along haulage and travel roads and air courses; (2) at the working face; and (3) in the parts where pillars are being removed.

59. Q. *What purposes or conditions are fulfilled by prop timbering?*

A. Prop timbering generally is used for three purposes or to meet three conditions: (1) To give support to the immediate roof strata over the opening and to assist in the equal distribution of the load on the pillars; (2) to make secure a bad and irregular condition of the roof; and (3) to give warning of any appreciable roof movement.

60. Q. *What preparation is required to prop a bad piece of top safely and efficiently?*

A. Careful testing of the roof, starting at a safe place, is the first essential; to insure the safety of the workmen safety props should be set as the work advances. Many mine accidents occur while men are digging hitches or doing other work preparatory to standing a prop. A safety prop should be used to protect them while they are doing this work. (*See* fig. 5.)

61. Q. *How does one know when and where to set props?*

A. In a newly developed mine, until a regular method of setting props has been evolved by experience and trial, miners and foremen always should take

FIGURE 5.—Adequate timbering and safety posts at the working face will prevent many roof-fall accidents. Note that miners are wearing safety goggles.

the precaution to set props under freshly exposed roof and run no risk of having men caught by falls of unsupported roof. Careful study of the roof should be the basis for planning a system of roof support.

62. Q. *What are the main requirements of good timbers?*
A. They should be of proper length and straight-grained, with a large enough sectional area and ends sawed square. (*See* figs. 6 and 7.)

63. Q. *What should be the condition of timbers delivered to working places?*
A. They should be solid and sound throughout.

64. Q. *When should broken, rotten, or defective timbers be replaced?*
A. Broken timbers should be replaced immediately; rotten timbers should be replaced at the first sign of deterioration; defective timbers should never be used.

65. Q. *What timbers should be furnished?*
A. Enough props, caps, and timbers should be furnished where required.

66. Q. *When should a miner notify his mine foreman of how many props, cap pieces, and timbers he requires?*
A. At least 1 day in advance. (*See* fig. 8.)

67. Q. *When is it unnecessary to order timbers 1 day in advance?*
A. In an emergency.

68. Q. *How should a working place be timbered?*
A. It should be substantially secured by props or timbers according to a predetermined plan or system of timbering.

69. Q. *What should be done before new places or slabs are started?*
A. Safety posts should be set.

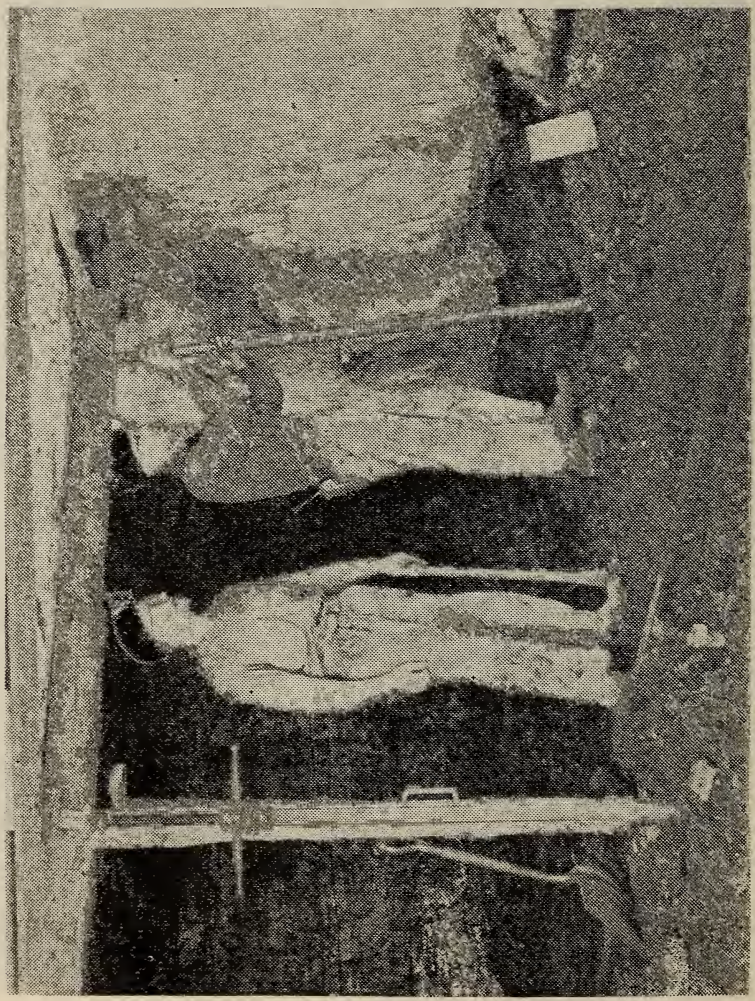

FIGURE 6.—A measuring stick should be used, so that timbers can always be cut to the proper length.

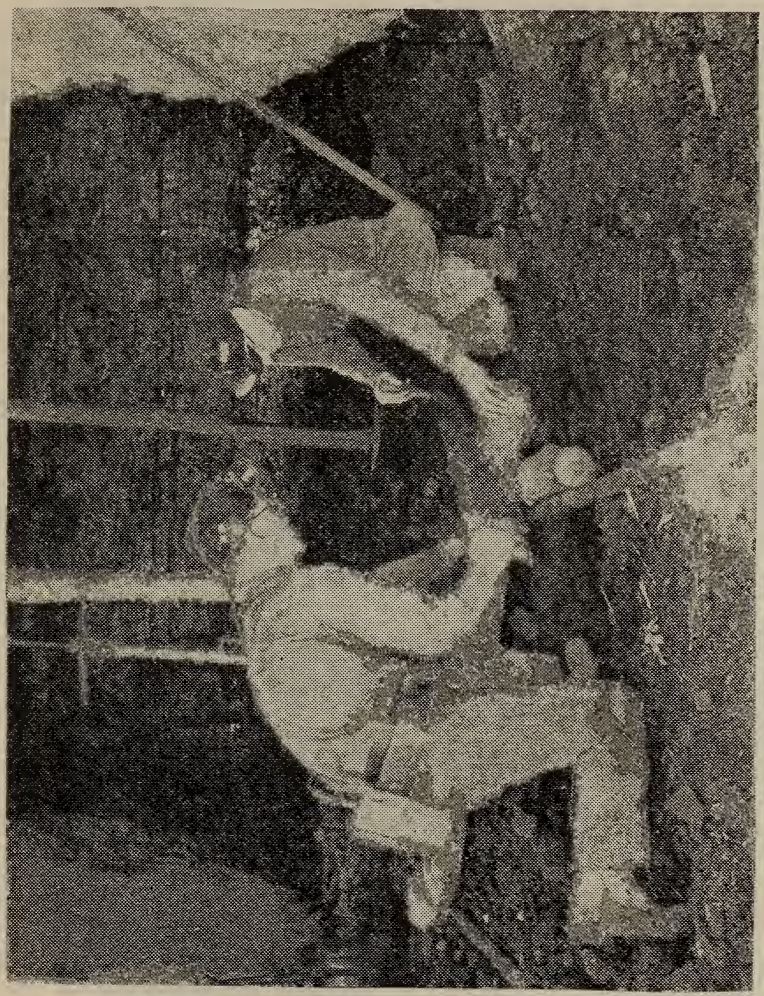

FIGURE 7.—A saw rather than an axe should be used for trimming timbers.

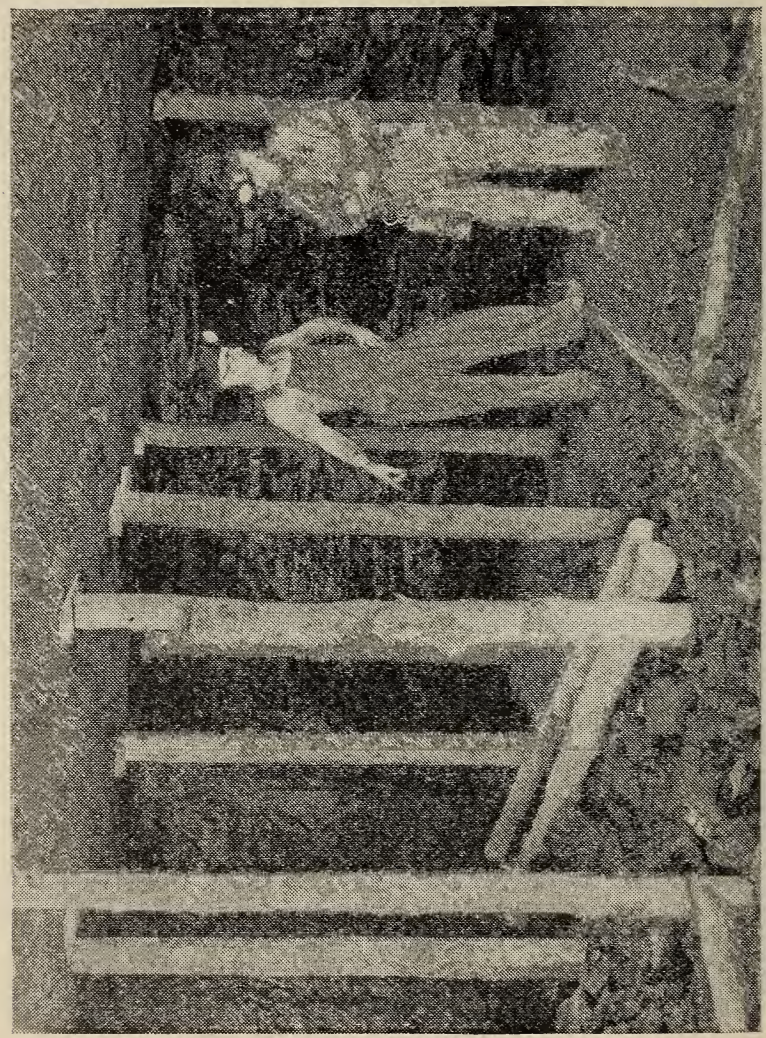

FIGURE 8.—Miners should order timbers before they are actually needed; they should be supplied promptly so that every working place will have adequate roof support.

70. Q. *What should be done with loose material found overhead?*
    A. It should be removed or carefully secured.
71. Q. *What should be done with loose, dangerous, or unusual overhanging ribs or brows?*
    A. They should be removed or carefully secured.
72. Q. *How should timbers be placed with respect to the track?*
    A. So as to maintain continuous clearance of at least 30 inches between the farthest projection of moving equipment and the timbers on the clearance side of the entry and at least 12 inches between the farthest projection of moving equipment and the timbers on the trolley wire side of the entry.
73. Q. *When should safety posts be set?*
    A. As the coal is removed.
74. Q. *How should posts be set in a horizontal seam?*
    A. They should be set vertically.
75. Q. *How should a post be set in a pitching place?*
    A. With the top slightly up the pitch.
76. Q. *How close together should timbers be set?*
    A. This varies with the mine. They should be set close enough to secure fully all portions of the roof against falls, particular attention being paid to cracks and slips in the roof.
77. Q. *What method of timbering should be used when there are numerous fractures in the roof or it is extremely weak?*
    A. Headers should be used.
78. Q. *What is a header?*
    A. A beam to support the roof, either hitched into the ribs or set on legs.
79. Q. *What common errors are made in setting timbers?*
    A. Setting timbers on uneven surfaces, not setting them plumb, using inadequate or crooked timber, and

having too small cap pieces and not wedging them properly.

80. Q. *Will the use of props alone give proper protection against these roof dangers?*
A. Props alone will not always give protection. Where cracks, slips, and fossil stumps are in the roof or their presence is suspected, cross bars supported by props give better protection.

81. Q. *When a slip or crack in the roof is discovered, what should be done for protection?*
A. The roof should be timbered immediately, a prop being placed on each side of the slip plane or crack; then, one or more cross bars or collars should be placed across and wedged tightly underneath the slip or crack.

82. Q. *If the roof shows the presence of a kettle bottom or fossil stump, what should be done?*
A. A temporary prop and substantial cap piece should be placed under it immediately; then a cross bar or collar supported by props should be placed under it. Props should be placed on opposite sides of the kettle bottom, and a shot hole should be drilled into the kettle bottom or near its edge and charged with explosive; after the cross bar has been removed the shot should be fired, which, if placed properly, will cause the kettle bottom to fall. The adjoining roof should then be supported by timbers.

83. Q. *What other conditions bring about unusual or dangerous roof?*
A. Often when a fault, dike, or horseback in the coal is being approached the roof requires essentially the same treatment as when slips are found.

84. Q. *Are miners required to set props for the support of the roof?*
A. The laws of all the coal-mining States require that miners set props for protection against the danger

of roof falls; that they shall examine their working places, especially as to the roof, and either take down loose roof material or make it secure with props or timbers; and that *they shall vacate the place if the necessary timber is not at hand.*

85. Q. *How do miners get timber?*

A. Under State laws the operator must furnish the props, caps, and other pieces of timber required at a place convenient for the miners' use (*see* fig. 9); in general, they should be of approximately proper lengths and cut square at one or both ends.

86. Q. *How may miners know if they are protecting themselves properly against falls of roof?*

A. Experience in different mines or parts of the same mine and the knowledge gained in testing, taking down, and supporting roof should be of value as a guide; State laws require that miners' working places be visited at regular intervals by an official of the company, generally the mine foreman or underground manager, who is required to see that the roof is made secure. An official should not permit men to work in an unsafe place, except for the special purpose of making it safe.

87. Q. *How often should an official visit miners to see that they are giving proper attention to the roof?*

A. Visits should be made as often as necessary to make sure that miners are not neglecting to support the roof or coal properly. Careful miners need little supervision, while others require frequent visits to see that they do not neglect the roof. At some mines, it is the practice to have an assistant foreman or a face boss visit each working place once each hour during the working shift.

88. Q. *What is the practice in coal mines for taking care of roof on haulageways and travelways?*

FIGURE 9.—Timbers and cap pieces should be stored in room necks or crosscuts, or other places where they will not obstruct the clearance along haulage roads.

A. Sometimes a timber crew in charge of a foreman is employed to remove fallen roof material and put timber to secure the roof. Sometimes this timber crew also puts up timber in any part of the mine where cross bars are required.

89. Q. *Are there some details about props and timber and the method of their use that miners and timbermen should know to use them to the best advantage?*

A. There are many features about timber and its use that should be known by miners and timbermen if it is to be used to the best advantage for safety.

90. Q. *If it is necessary to reduce the size of an individual post, is it better to saw the post down or split it?*

A. It usually is better to split posts, especially those from cone-bearing trees, as splitting does not destroy the sap wood or unduly injure the grain or fiber of the stick. If a prop or post must be shortened, the ends should be sawed off square and parallel to each other and not cut with an ax.

91. Q. *Is round, square, or split timber equally suitable for use as props?*

A. Round timber, free from bark and well-seasoned, is more serviceable than square or split timber.

92. Q. *Is a green prop as suitable as a seasoned prop?*

A. No, a properly seasoned prop will support more weight than the same prop when green.

93. Q. *Has the character of the roof or bottom anything to do with the manner of setting a prop?*

A. If the bottom is soft, the prop should be set either on a footboard or if not too thick the soft bottom should be dug out and the footing smoothed off. If the roof is coal or yielding material, a cap should be placed against it. The size of this cap can be determined only by trial, but a good rule is to use a cap half as thick as the top end of the prop, fully as wide as the prop, and approximately 18 inches

long. If a longer cap is used, its thickness should approximate the diameter of the top of the prop. Wedges at least as wide as the top of the prop should be driven between the prop and the cap. For roof that is hard and unyielding, a prop may be used without a cap, but double wedges not less than 12 inches long and as wide as the top of the prop should be driven between the roof and the top of the prop.

94. Q. *Do props with tapered ends have any advantages under certain special conditions?*

A. Yes; where the roof and bottom are strong and it is desired to have the roof gradually settle or the bottom heave without breaking the props. Under such conditions, props should not be driven tight, and cap pieces of soft timber should be used. The face of the tapered end usually is about 3 inches in diameter and about one-fourth the area or section of the body of the prop.

95. Q. *What should be the diameter of a mine prop?*

A. For the thinnest coal beds, the diameter of a prop should not be less than 5 inches at its smaller end. For roof that is more than 3 feet above the floor, it is good practice to use props that are at least 1 inch in diameter for each foot of length of the prop.

96. Q. *Is it true that the stronger the roof, the stronger the props must be?*

A. Yes; because when the roof is broken, it breaks into much larger pieces, requiring heavier posts set closer together.

97. Q. *Where should cross bars be used?*

A. Cross bars should be used where the roof material is scaly and soft and has slips or kettle bottoms or where the roof is likely to become loose over tracks, machinery, or other equipment.

98. Q. *What should be the size of a wood cross bar?*
A. In general, a cross bar should never be less than 3 inches thick and 10 inches wide; these dimensions would apply where the coal bed is thin and where thicker cross bars would interfere with the passage of mine cars. Where space or height will permit, it is good practice to use a cross bar as thick as the diameter of the middle of the supporting prop; round timber may be used where height will permit.

99. Q. *Will a cross bar support as much weight as the props that hold it in place?*
A. No. Much less weight will bend or break a cross bar where the load is near its center or is distributed over its entire length than is required to bend or break the supporting props.

100. Q. *How do cross bars add to the safety of miners?*
A. If the material over a cross bar begins to move and break away from the overlying strata the cross bar may give warning through preliminary cracking, retard falling, or hold the loose material for a time. Bending of a cross bar usually warns when it is overloaded; when this occurs it should be reinforced or taken down immediately along with the loose roof material; the place should be retimbered if the room remains dangerous.

101. Q. *What tools are required for setting props in a workmanlike manner?*
A. 1. Suitable testing tool. (As previously described.)
2. Measuring stick.
3. Pick.
4. Shovel.
5. Handsaw or crosscut saw.
6. Short-handed ax.
7. Sledge hammer of suitable weight.
8. Wedges.
9. Trimming bar with guard on handle.

102. Q. *How should miners measure for a prop?*
A. They should have two sticks of wood each about 1 inch thick, 2 inches wide, and about 1 foot longer than half the height from roof to floor. When the place for the prop is prepared, the sticks should be held firmly for use in measuring the length of timbers required, allowances being made for the cross bar, cap, or wedges.

103. Q. *What is a cap piece?*
A. A short piece of wood placed over the prop to give it a firm bearing and provide additional supporting area.

104. Q. *Of what kind of wood should cap pieces be made?*
A. Of softwood.

105. Q. *What are the advantages of using a cap piece under a prop?*
A. It affords greater protection for the prop and a greater bearing area for a soft bottom.

106. Q. *What should be the size of cap pieces?*
A. They should be wide enough to cover fully the end of the prop, long enough to extend for several inches beyond the edges of the prop, and at least 3 inches thick.

107. Q. *What is the purpose of a cap piece when used with a prop?*
A. The primary purpose of a cap piece is to lengthen the useful life of a prop. Where the top is soft and brittle but not heavy, a cap piece put against the soft roof material distributes the resistance of the prop over a larger area and at the same time tends to prevent the top of the prop from splitting. Where the top is heavy and pressure comes on the prop, the fibers of the wood in the cap piece directly over the prop tend to flatten and squeeze together, thus taking up part of the initial load, and the

unsupported part of the cap forms a protective ring of uncrushed fibers around the edge of the top of the prop, which tends to prevent the splitting of the prop and thereby gives the prop additional strength.

108. Q. *Should props be set without caps or wedges?*
A. All props should have either a cap or wedge; where the prop is too short, wedges should be used between the prop and the cap piece.

109. Q. *In setting a prop with a cap only, how is the prop made tight?*
A. The prop is cut slightly longer than the height of the roof less the thickness of the cap, and the prop is driven into position by a sledge.

110. Q. *In which direction should a cap piece be pointed?*
A. The cap piece should be pointed toward the working face. If a flying piece of coal should hit the prop when set in this manner, the cap, if wedge-shaped, would tend to tighten.

111. Q. *In what direction should the cap piece be placed on posts with reference to cracks in the roof?*
A. Where no cracks appear in the roof the cap pieces should be placed parallel to the track and pointed toward the face; where a crack occurs in the roof, it is essential, of course, that the cap piece be placed at right angles to the crack.

112. Q. *Can slate be supported better if large cap pieces are used?*
A. Yes; up to a certain point. Cap pieces should be of softwood at least 3 inches thick, 18 inches long, and as wide as the top of the post. In some mines, "half-headers"—half a cross bar—are used along entries. However, the cap piece can be too thick and also too long for either safety or efficiency.

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113. Q. *What is good practice for protection against falls at the working face?*
A. A safety prop or props should be placed within 3 or 4 feet of the face of the coal, depending on the condition of the roof material. Absence of safety props has cost many lives.

114. Q. *Should safety props be set on bottom coal?*
A. Safety props should not be set on bottom coal unless a suitable bearing board (or cap piece) is placed under the prop.

115. Q. *How should safety timbers be removed?*
A. If temporary or safety timbers must be removed before permanent timbers are set to support the same roof area, the roof should be examined and tested. It is safer to knock out the safety timbers with a long timber or post so that no miners will be under the roof if it falls.

116. Q. *Is it advisable to set temporary posts preparatory to taking down loose roof?*
A. Where the surrounding roof appears to be weak it is advisable to set temporary posts before taking down loose roof.

117. Q. *Should machinemen replace safety props they have removed when cutting across the face?*
A. Many machinemen have been killed by falls of roof at the face. Machinemen should replace promptly any posts they have removed, either accidentally or purposely.

118. Q. *Is it good practice to support the ends of cross bars in niches cut into the solid coal?*
A. Where the coal is solid, strong, and firm it is good practice to support one or both ends of a cross bar in the coal.

119. Q. *Where may short plumb posts be used to support collars in entries?*

A. Only where the coal is firm and strong and shows no tendency to spall; also where strong bands appear in the coal.

120. Q. *Are lagging bars supported by cross bars effective in holding the roof in place?*

A. Where the roof material is scaly and tends to become detached from the roof material above it and falls in relatively large pieces, lagging bars or stringers are used in narrow rooms and in temporary entries. For permanent use, it is not good practice to bring excess weight in the center of a cross bar, as it is liable to break and cause the roof material to fall.

121. Q. *When a cavity occurs in the roof from a fall of material and pieces continue to drop from the exposed surface of the cavity and thus enlarge it, what method of treatment is practicable?*

A. The cavity left by a fall of material may become enlarged gradually and affect the roof for a long distance. The object is to catch up the roof; this may be accomplished by erecting cross bars under the cavity and building on them a structure or cog of timber to support the lagging bars, which may be props or mine ties.

122. Q. *What is the safest method of recovering timber, and what precautions should be taken?*

A. The safest method of removing timber is to use a mechanical or hand-operated post puller that will enable the operator to stand under sound roof that is properly supported by timber. A sledge hammer or ax should never be used for knocking out posts, and the path of retreat must be kept clear, to afford opportunity to get out of the way if necessary.

PREVENTING ROOF AND COAL ACCIDENTS IN MECHANIZED MINING

123. Q. *What timbering regulations are necessary for safety in mechanical loading?*

A. A plan of systematic timbering should be adopted to suit the mechanical loading equipment and the character of the roof and coal. The employees, the company, and the State mine inspector should agree on the plan, which then should be followed in every detail. Provision should be made for the use of additional timber when needed. The timbering plan should include the setting of temporary props or cross bars whenever the removal of props is necessary to the operation of the loading machine, conveyor, or cutting machine. The method of timbering should require minimum resetting of timber.

124. Q. *What are the duties of the face boss with respect to systematic timbering?*

A. The face boss should see that timbering is done systematically and maintained at all times, particularly near the face, in accordance with the plan agreed upon by employees and officials. He should see that an ample supply of timber, cap pieces, and wedges of proper size is available relatively close to the working face at all times. (*See* fig. 9.)

125. Q. *What precaution should be taken with conveyor suspension with reference to roof-fall hazards?*

A. Conveyors, if suspended, should be hung so that there is no danger that their motion will loosen the roof and cause roof falls. Sometimes the props from which conveyor pans are hung are set in a line at right angle to the direction of the pan line, which throws undue stress on one or more props and tends to loosen them.

126. Q. *Should caution be used in blasting coal when mechanical loading is used?*

A. Yes. Holes must not be drilled too near the roof because the explosives may break the roof and cause it to fall or become loose and dangerous for the loading-machine crew. When the coal is not broken properly, the machine operator has to dig it with the loading machine. This practice sometimes causes the rear end of the machine to swing one way or the other and knock out props. Excessive charges of explosive or insufficient or inefficient stemming may cause blown-out shots or excessive throwing of coal, which in turn may knock down props or other timbers.

127. Q. *What precautions should be taken after blasting to avoid roof-fall hazards if blasting is done on the shift?*

A. Gases from explosives or Cardox should be allowed to clear out thoroughly until good normal visibility is restored in the place. Then the face boss or person in charge of the crew should examine the place for gas and test the roof and the coal thoroughly. Props or cross bars should be set where needed or reset when blasting has loosened, damaged, or knocked them down. Some of these may have to be temporary supports to be replaced when coal is loaded.

128. Q. *If it appears impracticable to set the needed number of props to safeguard a place properly and still operate a mechanical loader, what other timbering protection should be employed?*

A. Cross bars supported on posts or in hitches cut in the coal may be used; some companies use steel H-bars supported on wood or steel posts and installed parallel to the face. A third post can be placed

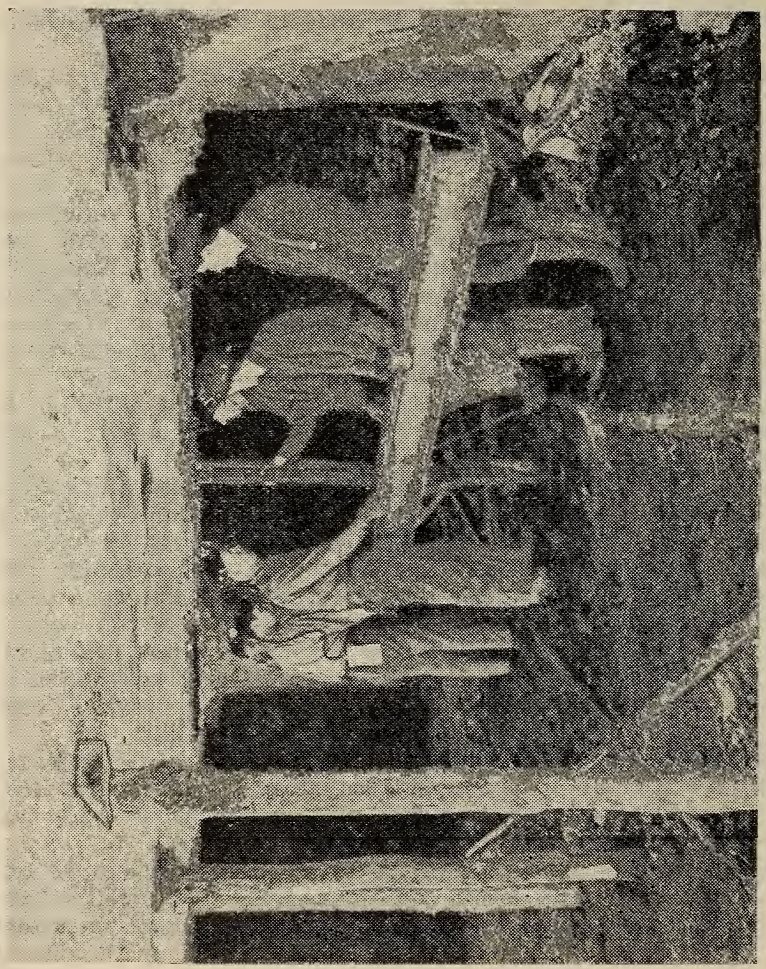

FIGURE 10.—Heavy cross bars should be lifted and supported by a timber jack. The timber jack is a real safety device and makes the timberman's work much easier.

under the H-bar at a convenient point and moved to suit the position of the loading or cutting machine. When two such bars are used as the face advances, the rear bar can be dropped after each cut and moved up to the face. (*See* fig. 10.)

Another scheme used in connection with a track-mounted cutting machine is to invert the cutter bar and cut hitches into the ribs close to the roof, into which a steel rail can be inserted for roof protection. Later this rail can be taken out or posts can be put under it.

129. Q. *What type of temporary props should be used?*

A. Temporary wood props should be of good substantial timber with good cap pieces and should be set as firmly as permanent props. Metal screw jacks and other types of adjustable props make good temporary props and are quickly set and taken down.

130. Q. *In mechanical loading, what precautions should be taken with props that may be knocked out by the loading machine?*

A. 1. Any props that are directly in the track or that may be knocked down should be removed before the loading machine enters the working place.
2. Loose material should be barred down.
3. The roof around the props should be examined.
4. One or more temporary props should be set as close as possible before the prop is knocked out.
5. If the roof is broken or dangerous, long headboards or cross bars should be used to cover the area from which the prop is removed.

131. Q. *Should the operators of mobile loading machines knock out props under loose roof with the head of the loading machine?*

A. No; this practice is definitely dangerous and has caused the death of a number of loading-machine men. If the roof is bad, a timberman should set

cross bars or other props to support the roof at the point where the prop or props are to be taken out and should then remove the prop that obstructs operation of the loading machine.

132. Q. *Can the prop line be maintained near the face while the coal is being loaded?*

A. Yes; after the place has been timbered according to the standards the timberman can mark places on the roof, between the prop line and the face, where props should be set. He should then prepare and mark props for these places and place them a suitable distance from the face. As the coal is loaded, these props can be set in a very short time and the loading-machine crew protected thereby.

133. Q. *How near the face should the prop line be maintained, and what roadway clearance should be allowed?*

A. The prop line should be maintained as near the face as possible when the roof is good. Some companies have adopted the system of maintaining the prop line within 8 or 10 feet of the face before the coal is blasted.

The clearance between the track and roadside props will depend on the condition and quality of the roof and the type of loading machines used. Some companies using mobile loading machines have standardized on setting the roadside props 36 inches from the track on the side of the machine operator and 30 inches on the opposite side.

134 Q. *When should the working places be timbered?*

A. As soon as possible after the loading machine has loaded the coal and before other employees, except timbermen, enter the place. This will protect the cutting-machine operators, drillers, "bug-dust" shovelers, tracklayers, or other employees who may have to work in the place before the face is blasted again. (*See* fig. 11.)

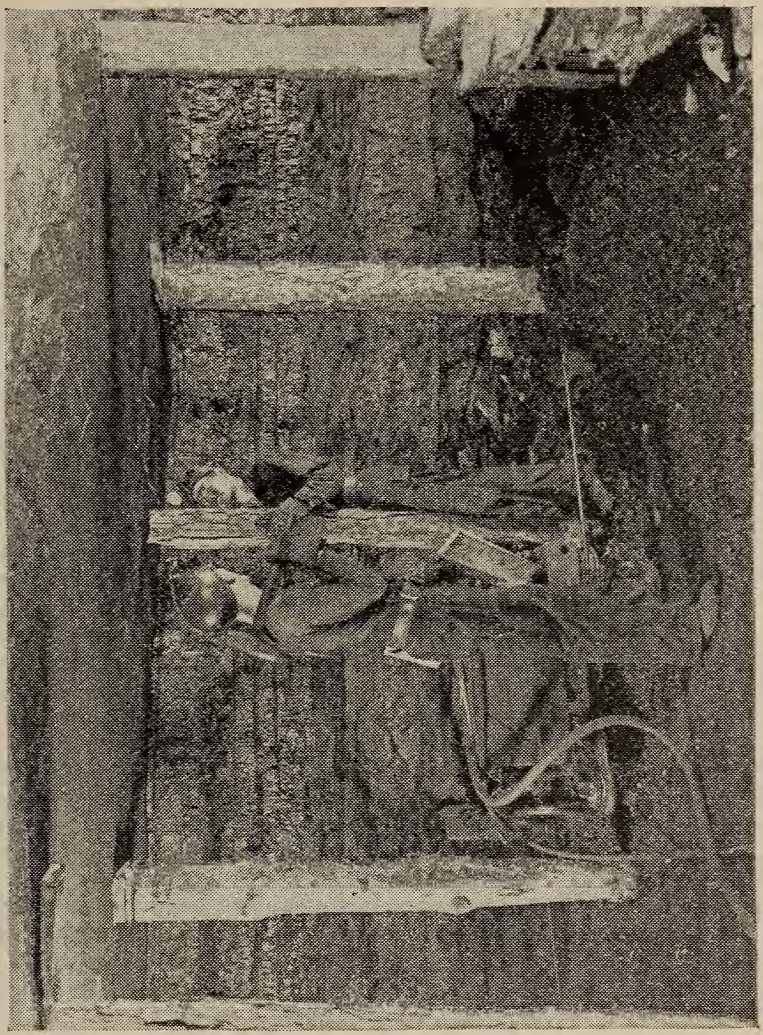

FIGURE 11.—When safety posts are removed to permit movement of the mining machine across the face, they should be replaced promptly.

135. Q. *Is it important and necessary to test roof systematically in mechanical loading?*
A. Yes; it is as important and necessary in mechanical loading as it is in hand loading.

136. Q. *What other precautions should be used to lessen the likelihood of accidents from roof falls?*
A. Machinery should be stopped often in a working place to determine whether any of the roof or coal is "working" and to permit better inspection of the place.
When bad top is found, the room width must be narrowed. Enough timbermen and maintenance men should be used to safeguard the working place and keep equipment in proper and safe condition.

137. Q. *What system of roof testing should be used?*
A. Of any single method, the vibration method is the best. The tips of the fingers are placed on the roof, and the roof is struck with some object such as a sledge or bar; then the condition of the roof is determined by the intensity of the vibration felt through the finger tips. However, sight and sound should also be considered. Coal and cap or other pieces of wood should not be used for testing roof. It is believed that a short, heavy bar is the best instrument for this purpose. Some companies place sounding bars on the loading machine as part of the necessary equipment.

138. Q. *When should the roof be tested?*
A. Before a loading machine enters a place someone should test the roof and either pull down or timber any loose roof. When the loading-machine crew enters the place it also should test the roof to see that it is safe to work under, and should test it at regular intervals while the coal is being loaded. This can be done while car changes are being made.

139. Q. *What common practices cause failures in roof or coal support in mechanical loading?*

A. Sometimes too little timbering has been used at conveyor discharge points, or it is crushed or so placed as to allow too little clearance for the men between cars, timber, and rib. Props sometimes are set loosely or poorly and with poor cap pieces and wedging. Props, particularly temporary props, may be lacking where needed. Cross bars may be needed. In mines where the coal has numerous slips or tends to overhang or roll out in chunks, sprags must be used in undercut places. Frequently they are not used under such conditions.

PREVENTION OF ACCIDENTS FROM MINE HAULAGE

TYPICAL EXAMPLES OF HAULAGE ACCIDENTS

1. A machine helper was walking along a shop track nipping a locomotive from a spur track onto the main track. When the hooked nip caught and hung at a trolley hanger he attempted to get in the deck on the front end of the locomotive to shut off the power at the controller; he slipped and fell under the locomotive and was killed.

A locomotive should not be moved unless an operator is in the deck at the controls; a hooked nip should never be used for this purpose.

2. A brakeman had thrown a room switch and had stopped in the space between the tracks and beyond the frog while cars were being pushed into the room. The cars were derailed at the frog, and the brakeman was crushed to death between the corner of the car and a post.

Brakemen and others should keep well in the clear when trips of cars are passing; moreover, good track will help prevent derailments.

3. A motorman was operating a locomotive which was pulling a trip of loaded cars up a 2-percent grade. When the loco-

motive was derailed, the motorman jumped out on the tight side and was crushed between the rear of the locomotive and the rib.

Such derailments can be prevented by the installation and maintenance of good track and rolling stock. (*See* figs. 12, 13, 14, and 15.)

4. A driver was driving a string of three mules pulling a car from the working face. The grade was outby the frog and a helper was in the act of controlling the brake from the rear of the car. As the car passed the frog, the helper heard the driver call and immediately stopped the car. Apparently the driver had tried to get on the front bumper, and slipped and fell under the car, where he was killed.

No one should ever attempt to ride the front bumper of a car or trip of cars.

5. A brakeman was riding the front bumper of a locomotive, which was entering a place to get a loaded car. He was caught by a low roll in the roof and rolled back over the cable reel and fatally injured.

No one should ever ride the front bumper of a locomotive. The safest place is in the cab of the locomotive or the rear bumper when the locomotive is going forward. (*See* fig. 16.)

6. Three loaded cars had been placed inby a switch leading to a place being cut. As the locomotive passed over the switch, the wedge used to block the cars evidently was dislodged. While the machineman was loading his machine, he was crushed against the rib by the runaway cars.

This fatality was caused by failure properly to block cars left standing on grades; wedges are not considered adequate blocking.

7. A car dropper was dropping a loaded car from the tipple. As he released the brake, he slipped and fell in front of the moving car, which ran over him, killing him instantly.

The use of a safety belt by car droppers would prevent accidents of this type. (*See* fig. 17.)

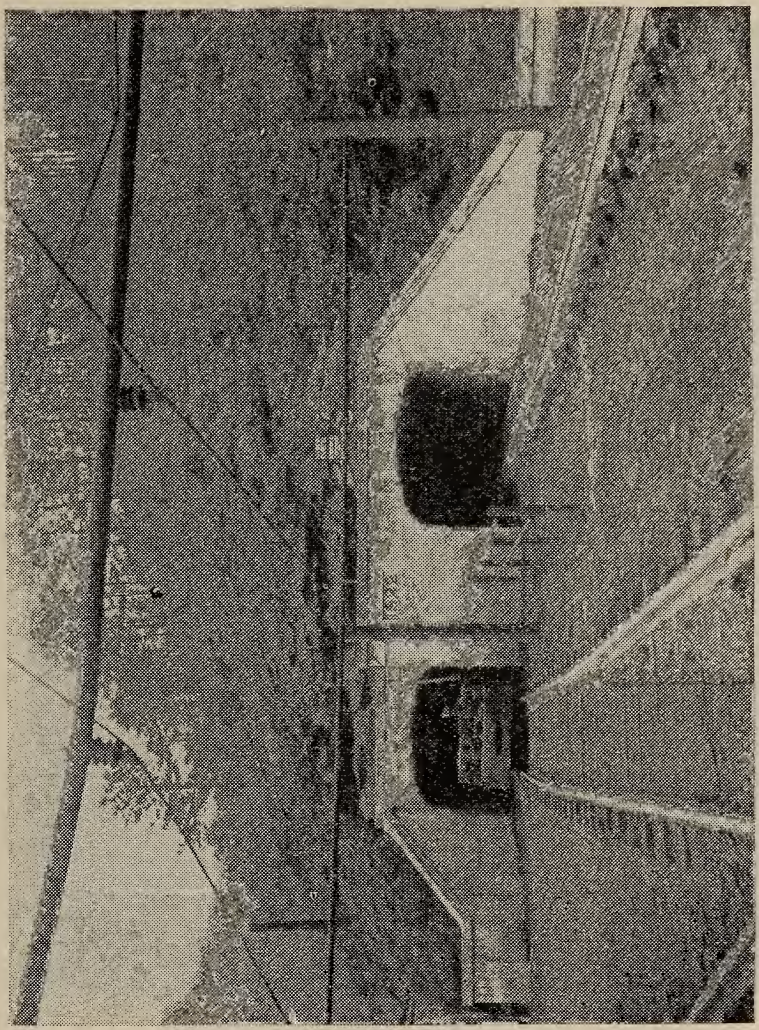

FIGURE 12.—Good track and roadbed are essential for a safe and efficient haulage system.

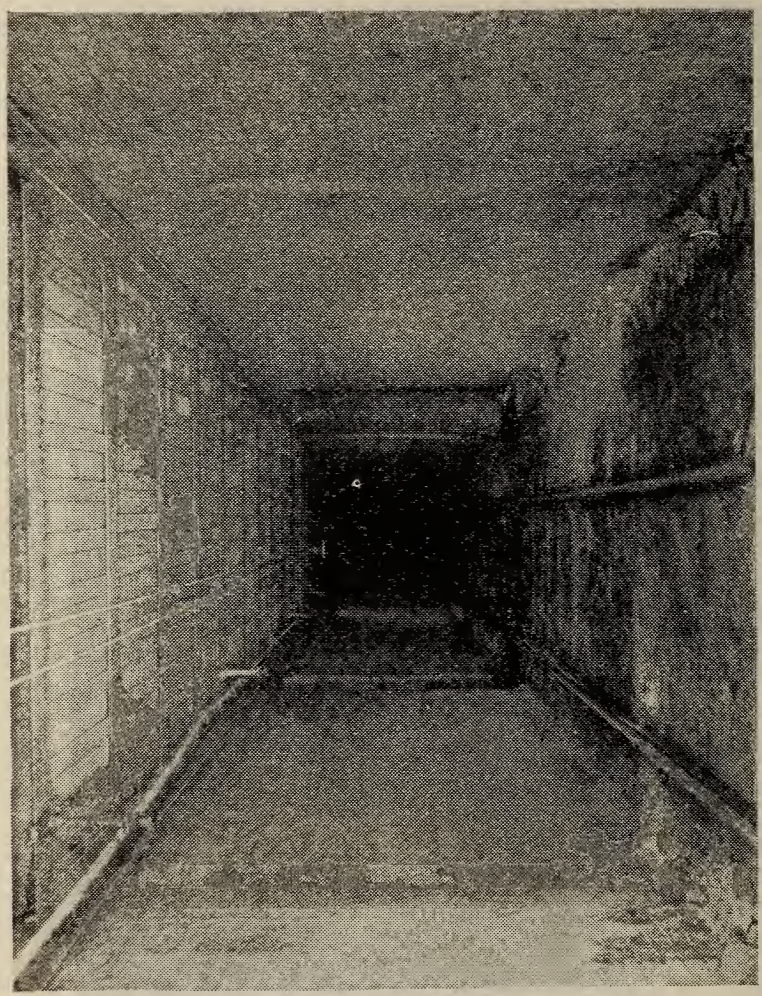

FIGURE 13.—Good track and well-supported roof and sides are essential to safe mine haulage.

FIGURE 14.—Good track at the face, properly alined and secured with splice bars, will prevent many accidents from mine cars.

FIGURE 15.—The shaft bottom, which is the terminal of the haulage system, should be kept in perfect condition.

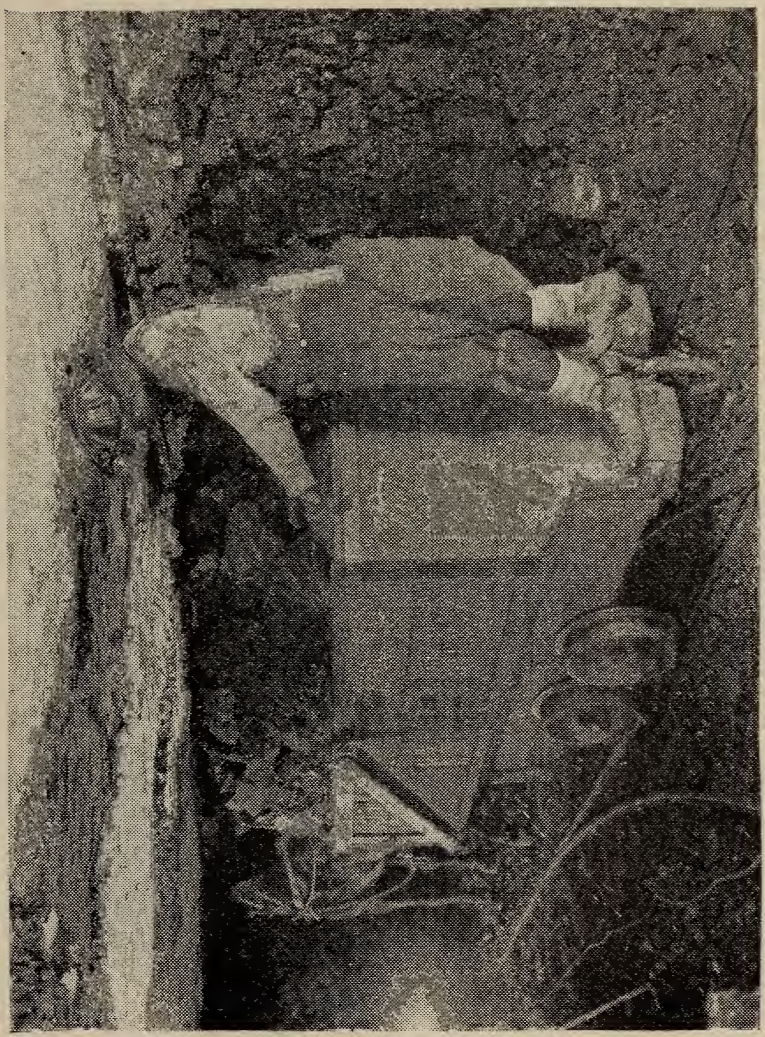

FIGURE 16.—The rear bumper of loaded cars is the safest place for the driver to ride.

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FIGURE 17.—Car droppers should use safety belts when operating railroad-car brakes.

QUESTIONS AND ANSWERS

1. Q. *What is the second greatest cause of fatalities in coal mines?*
   A. Haulage.
2. Q. *How many underground coal-mine employees were killed by haulage accidents in the United States in 2 recent typical years?*
   A. 182 were killed in 1939 and 221 in 1940.
3. Q. *What percentage of the total number of deaths of underground coal-mine employees killed in 1939 and in 1940 was due to haulage accidents?*
   A. 18 percent in 1939 and 17 percent in 1940.
4. Q. *How many nonfatal injuries, due to mine cars and mine locomotives, occurred to underground coal-mine employees in the United States in 1939?*
   A. 9,755 nonfatal injuries.
5. Q. *What are some unsafe haulage practices?*
   A. Making flying switches, permitting men to ride on pushed trips, throwing switches and opening doors in front of moving trips, riding loaded cars, riding on the front bumpers of cars, leaving unblocked cars on track, coupling cars in motion, getting off or on trips in motion, and carelessness of haulage employees.
6. Q. *What safety devices can be used to prevent accidents from coupling cars?*
   A. Automatic or semiautomatic car couplings and coupling hooks where link-and-pin couplings are used.

CLEARANCE AND REFUGE HOLES

7. Q. *What should be done along haulage roads, slopes, and engine planes to increase the safety of persons required to work or travel along these haulageways?*

A. Adequate clearance should be maintained, and refuge holes should be provided.

8. Q. *What clearance should be maintained along entries between the car and the rib, gob, or timber for the passage of persons?*
   A. Not less than 30 inches.
9. Q. *Where should the clearance side along a track be situated relative to the trolley wire?*
   A. On the side of the entry opposite the wire.
10. Q. *What minimum clearance should be maintained on the wire side between the car and rib, gob, or timber?*
    A. Not less than 12 inches.
11. Q. *What should be the minimum clearance where supplies are unloaded?*
    A. 30 inches.
12. Q. *What provision should be made relative to leaving supplies along a haulage track?*
    A. All supplies should be unloaded in a break-through or other opening where the clearance will not be obstructed, and on the side opposite to the trolley wire unless the wire is fully protected.
13. Q. *What should be the minimum clearance along each track in sidetracks?*
    A. 30 inches.
14. Q. *What protection should be provided for pedestrians along haulageways?*
    A. Refuge holes should be provided and maintained.
15. Q. *What should be the maximum distance between refuge holes?*
    A. 60 feet, except at curves, where they should be not more than 30 feet apart.
16. Q. *What is the minimum size required for refuge holes?*
    A. 4 feet in width, 5 feet in depth.
17. Q. *How should refuge holes be maintained?*
    A. Free from obstructions, with the roof and sides made secure.

18. Q. *What protection from moving trips should be provided on both sides of permanent doors?*
    A. Refuge holes.
19. Q. *What protection from moving trips should be provided at switch throws?*
    A. Refuge holes.
20. Q. *When should refuge holes be used?*
    A. At all times when men encounter passing trips.
21. Q. *How should clearance points at the end of sidetracks be designated?*
    A. By being plainly marked.
22. Q. *Where should cars, locomotives, or other portable machinery not be placed on sidetrack?*
    A. Beyond the clearance points.
24. Q. *Where should cars, locomotives, or other portable machinery not be placed in the mouth of rooms or entries?*
    A. Outby the rib line.
25. Q. *Where should loaded cars not be stored between working shifts?*
    A. Under live electric wires.

BLOCKING OF CARS AND TRIPS

26. Q. *What safety devices should be used where track goes to the rise on producing entries?*
    A. Stopblocks or derails should be installed below the switch of the first active working place.
27. Q. *What safety devices should be used where track goes to the dip on producing entries?*
    A. Stopblocks or derails should be installed above the switch of the first and below the switch of the last active working place.
28. Q. *How should blocking devices be maintained?*
    A. In proper operating condition.

29. Q. *What devices should be provided at the face of each working place to prevent the car from moving?*
    A. Stopblocks or clevises. (*See* fig. 18.)
30. Q. *When a trip is uncoupled from a locomotive on a grade, what precautions must be taken?*
    A. Brakes must be set and the cars blocked properly.
31. Q. *What commonly used materials should be prohibited for blocking cars?*
    A. Wedges, cap pieces, or anything except approved devices.
32. Q. *What is meant by approved devices for blocking cars?*
    A. Any positive device that will effectively hold trips or cars in position on a grade, approved by the management of the mine.

MINE TRACK

33. Q. *What are the primary requirements of good mine track?*
    A. Rails should be of proper size, ties should be adequate in size and number and should be spiked to proper and uniform gage, joints should be well-bolted, and track should be kept clean and well-drained. Uniform grades should be maintained, and curves should be carefully installed.
34. Q. *What hazards are attendant on poorly maintained track?*
    A. All hazards incident to frequent derailments.
35. Q. *What are the primary causes of haulage accidents?*
    A. Insecure track, defective equipment, insufficient clearance, unsafe practices, and careless acts.
36. Q. *What should be the condition of track at working faces before cars are placed?*
    A. The track should be laid in a workmanlike manner and maintained properly.
37. Q. *Why should track be maintained properly at working faces?*

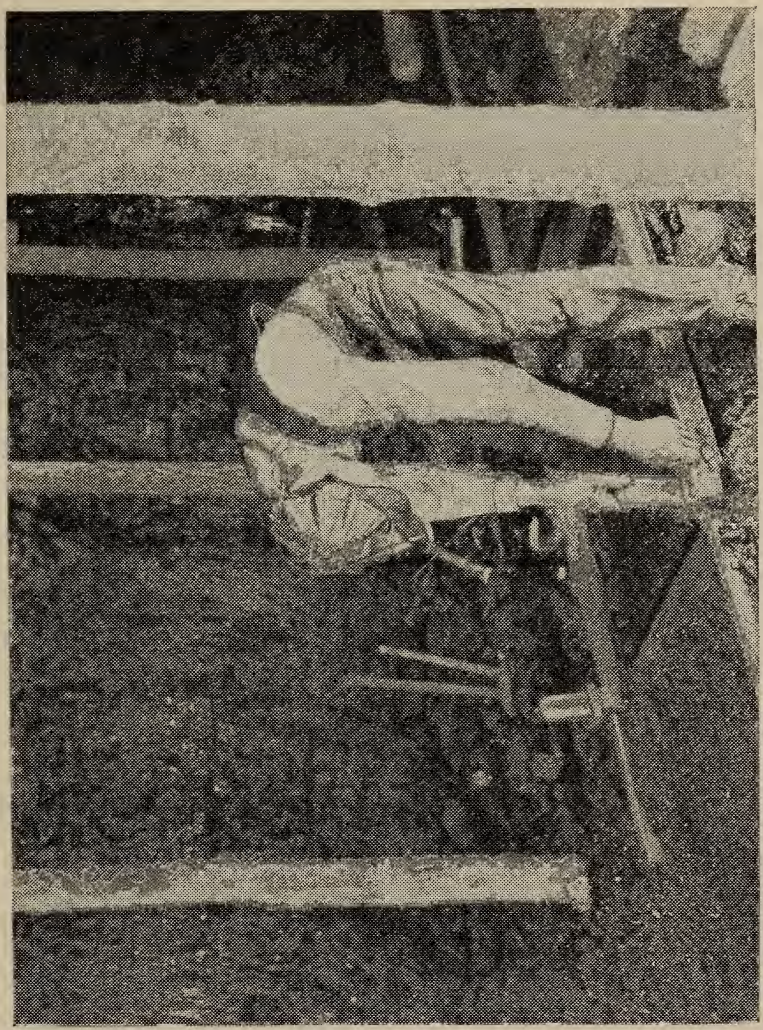

FIGURE 18.—Stopblocks or clevises should always be used at the end of the track in working places, regardless of the grade.

A. Because derailments at working faces which cause numerous accidents would be prevented.

38. Q. *In what condition should haulageways and travelways be maintained?*
A. Clean, orderly, well-illuminated, and free from anything that may cause tripping and falling. (*See* fig. 19.)

39. Q. *How should all rail joints be made?*
A. They should be fastened securely to each other by means of splice bars or fish plates.

40. Q. *What are the practical advantages of having properly installed turn-outs?*
A. The lurching of cars is lessened, derailments are decreased, and transportation can be carried on safely at higher speed.

41. Q. *What should be a requirement of switch-throw ties?*
A. They should be long enough to attach the switch throws.

42. Q. *Where should switch throws be located?*
A. On the side opposite the wire, where there should be not less than 30 inches of clearance.

43. Q. *What additional protection should be provided where switch throws are located?*
A. A standard shelter or refuge hole should be provided.

44. Q. *What kind of switch throws should be used?*
A. Automatic or parallel throws.

45. Q. *What parts are essential for throwing switches?*
A. Throws and bridle bars.

46. Q. *How should switches be maintained?*
A. In proper working condition, free from coal, dust, and dirt so that moving parts will operate easily.

47. Q. *How should switches be kept alined?*
A. With the main track (against working places).

48. Q. *Where should turn-outs be braced?*
A. Where necessary to maintain proper alinement.

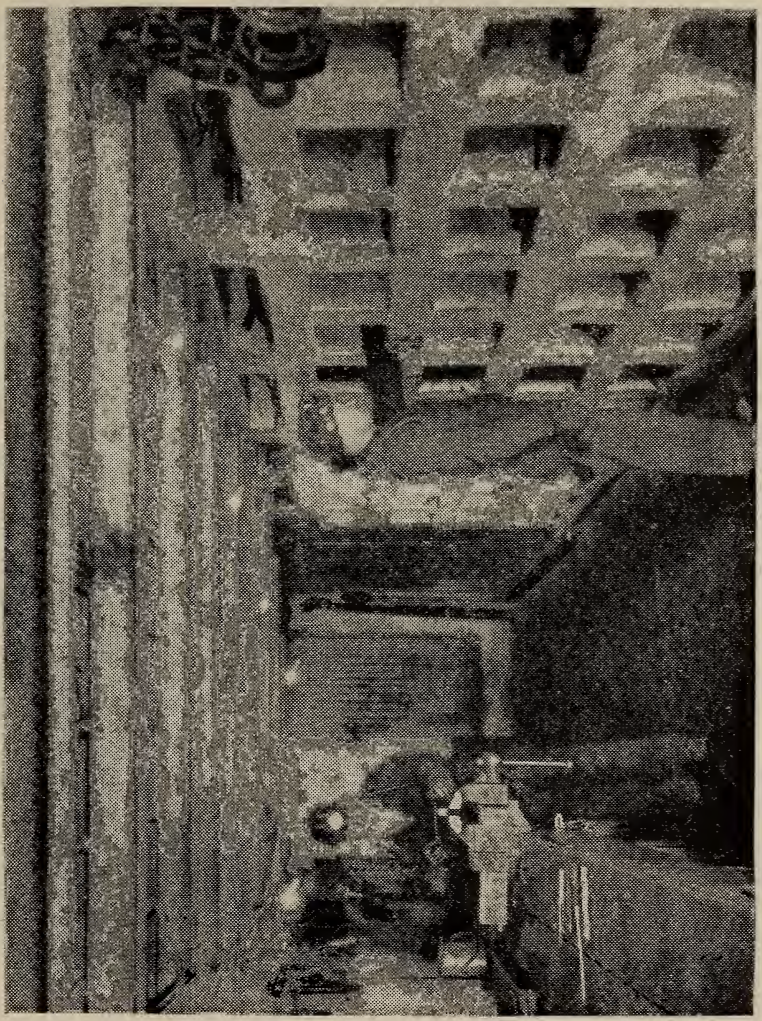

FIGURE 19.—Good housekeeping in repair shops and supply rooms is a necessary safety practice.

LOCOMOTIVES AND TRIPS

49. Q. *What should a person do before stepping out of a shelter hole immediately after a trip has passed?*
    A. Look for the rear light and for following traffic.
50. Q. *How are moving trips required to be lighted?*
    A. By a conspicuous light on both front and rear.
51. Q. *Who should see that a conspicuous light is placed on the front and rear of trips?*
    A. The motorman and trip rider.
52. Q. *What should be done if a locomotive headlight or trip light fails?*
    A. The locomotive or trip should not be moved until the light has been repaired or replaced.
53. Q. *How should a locomotive be lighted when it is traveling without cars?*
    A. By a conspicuous light on both front and rear.
54. Q. *How should the brakes on locomotives be maintained?*
    A. In proper operating condition.
55. Q. *When are locomotive brakes in proper operating condition?*
    A. When they will stop a standard trip, traveling at a standard rate of speed, within a distance of 100 feet on any grade throughout the road on which the locomotive is required to travel. (*See* fig. 20.)
56. Q. *How can a trip be kept under control on long descending grades where the locomotive is not heavy enough to control it?*
    A. By placing slides or skids under the car wheels.
57. Q. *What material should be provided on each locomotive to increase traction?*
    A. Clean, dry sand.
58. Q. *How should the sand rigging on locomotives be maintained?*
    A. In proper operating condition so that the sand can be released instantly at any time.

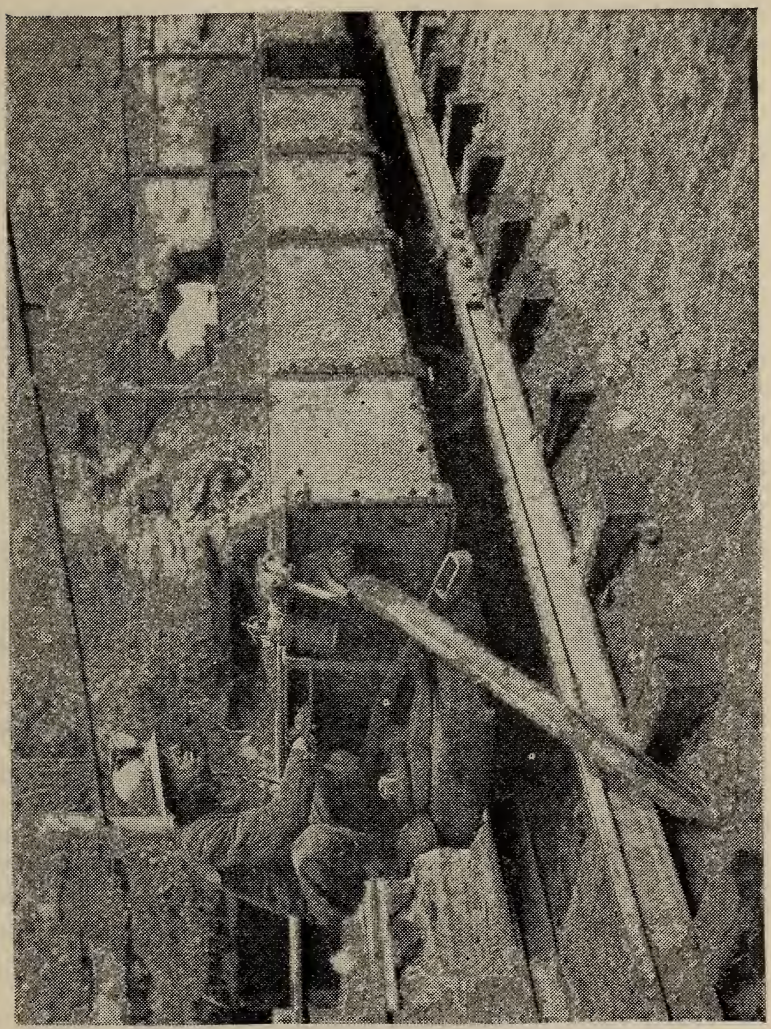

FIGURE 20.—An effective drag should be used on trips that are hauled on grades. Trip lights should always be used on the rear end of trips.

59. Q. *Why should sanding by hand be prohibited while the locomotive is in motion?*
    A. A hand or arm may be caught under the wheels.
60. Q. *How should the decks of locomotives be constructed to protect the operator from moving parts?*
    A. With shields.
61. Q. *What signaling devices should be provided on locomotives?*
    A. Gongs or other sounding devices.
62. Q. *What appliances are required as equipment for a locomotive?*
    A. A lifting jack and handle, a set of rerailers, a fire extinguisher, and a first-aid kit.
63. Q. *What is the duty of the motorman relative to the speed of transportation?*
    A. He should operate at such speed that he can keep his trip under full control at all times.
64. Q. *Where should the operator of a locomotive be while the locomotive is being operated?*
    A. In the deck of the locomotive.
65. Q. *What should be the minimum distance permitted between trips?*
    A. 500 feet.
66. Q. *What method should not be used for operating trips on main haulageways?*
    A. Trips should *never* be pushed. (*See* fig. 21.)
67. Q. *How should motormen operate trips when approaching and passing through doors or curtains?*
    A. At slow speed not to exceed 3 miles an hour, under full control, and able to stop immediately.
68. Q. *Where may cars and trips be left standing in a mine?*
    A. In a safe place where they will not endanger other trips or persons and will not obstruct the ventilating current.

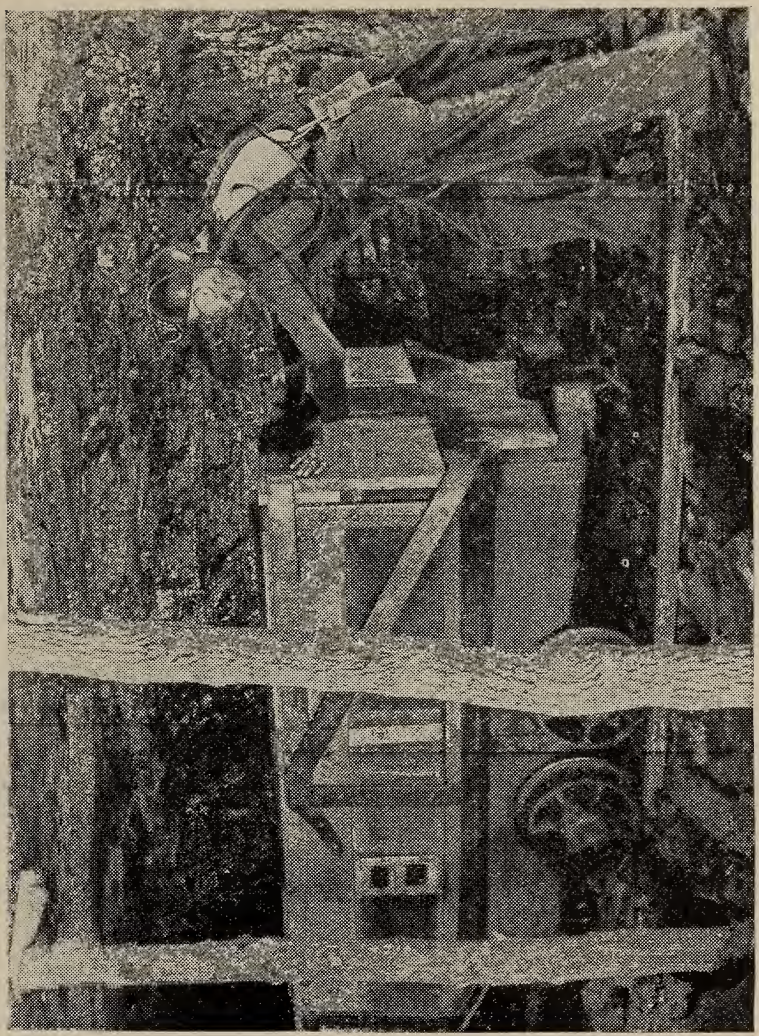

FIGURE 21.—In pushing cars by hand, the hands should be kept safely away from the top of the end gate or the sides of the car.

69. Q. *What protection should be provided for trips, locomotives, and other mechanically operated equipment coming out onto tracks used by other portable equipment?*
    A. Signals should be used.
70. Q. *What is the correct position for the trolley pole when a locomotive is in motion?*
    A. The trolley pole should be so placed that the trolley will trail the locomotive. Back-poling should be prohibited, except with extreme precaution to the nearest turning point.
71. Q. *What precautions should be taken while coupling cars?*
    A. The cars should not be in motion and the brakeman should stay on the clearance side only and avoid stepping between the bumpers. (*See* fig. 22.)
72. Q. *How can injuries to the fingers and hands of brakemen be avoided?*
    A. By the use of coupling hooks where link-and-pin couplings are used.
73. Q. *What should be done to regulate and safeguard the movement of trips?*
    A. A proper system of signals should be provided. (*See* fig. 23.)
74. Q. *What precautions should be taken before current is connected to locomotive or controller is opened?*
    A. Motorman should be in the deck and all persons and equipment in the clear.
75. Q. *From what side should cars be coupled?*
    A. From the opposite side from the wire or on the outside of a curve.
76. Q. *How may mine cars be coupled in safety?*
    A. By coupling when not in motion. (*See* fig. 24.)
77. Q. *How should a locomotive used at conveyor loading points be controlled and operated?*
    A. With an operator in the deck.

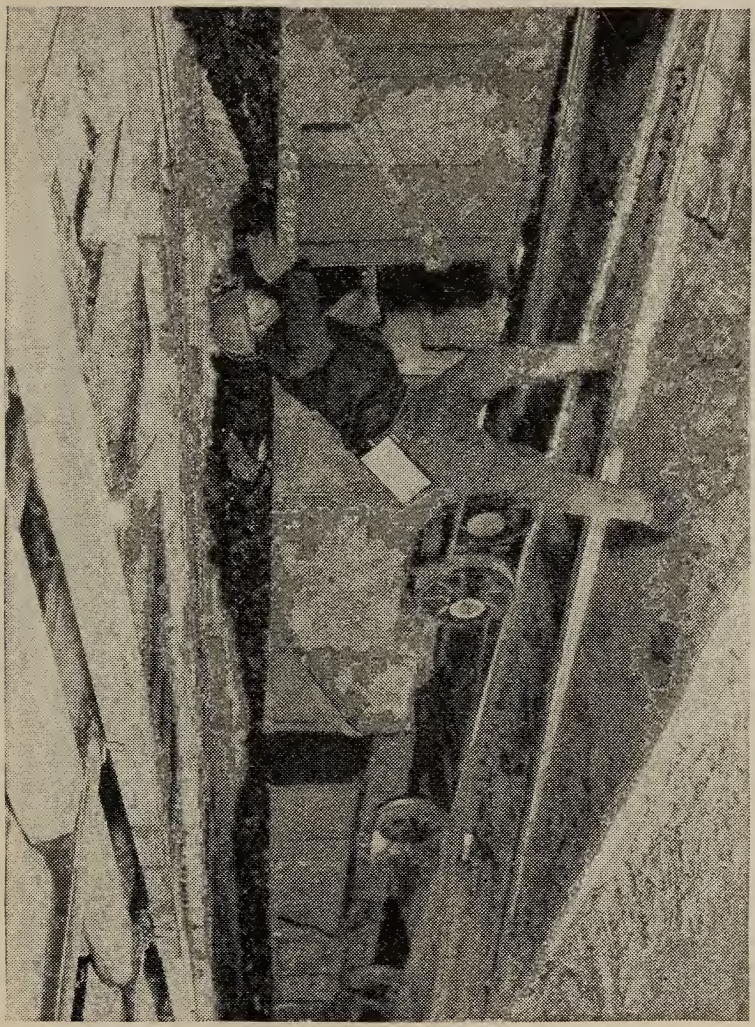

FIGURE 22.—For his own safety, a brakeman should keep in the clear when coupling cars.

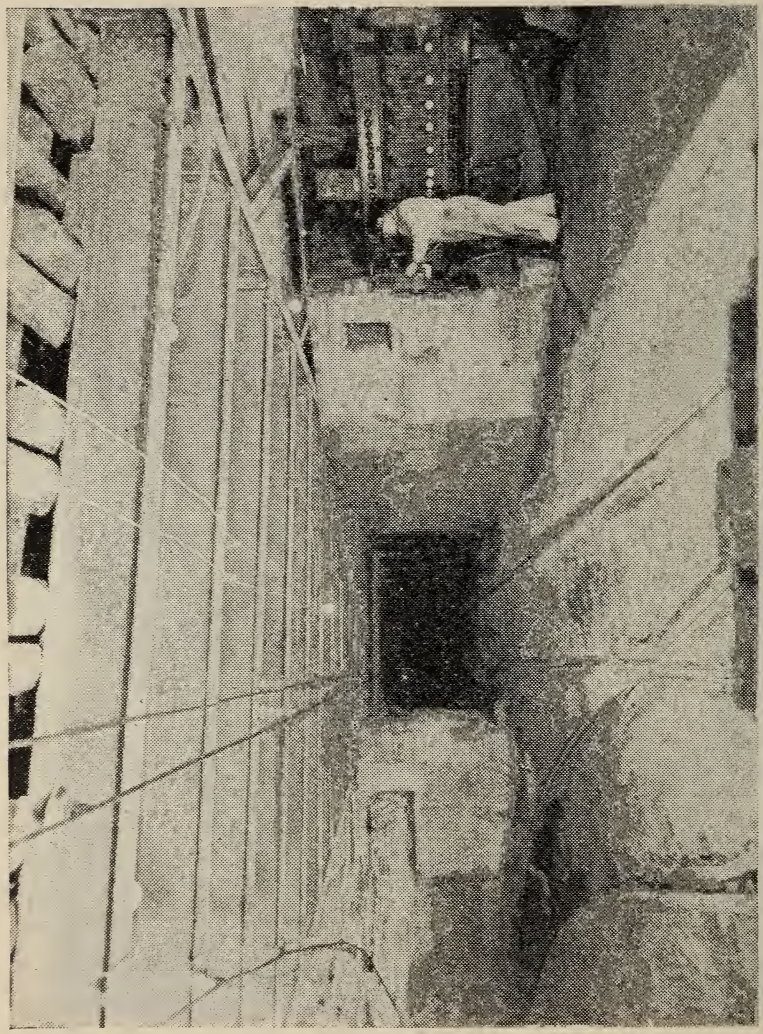

FIGURE 23.—The movement of trips should be controlled by a well-planned and properly installed dispatcher system.

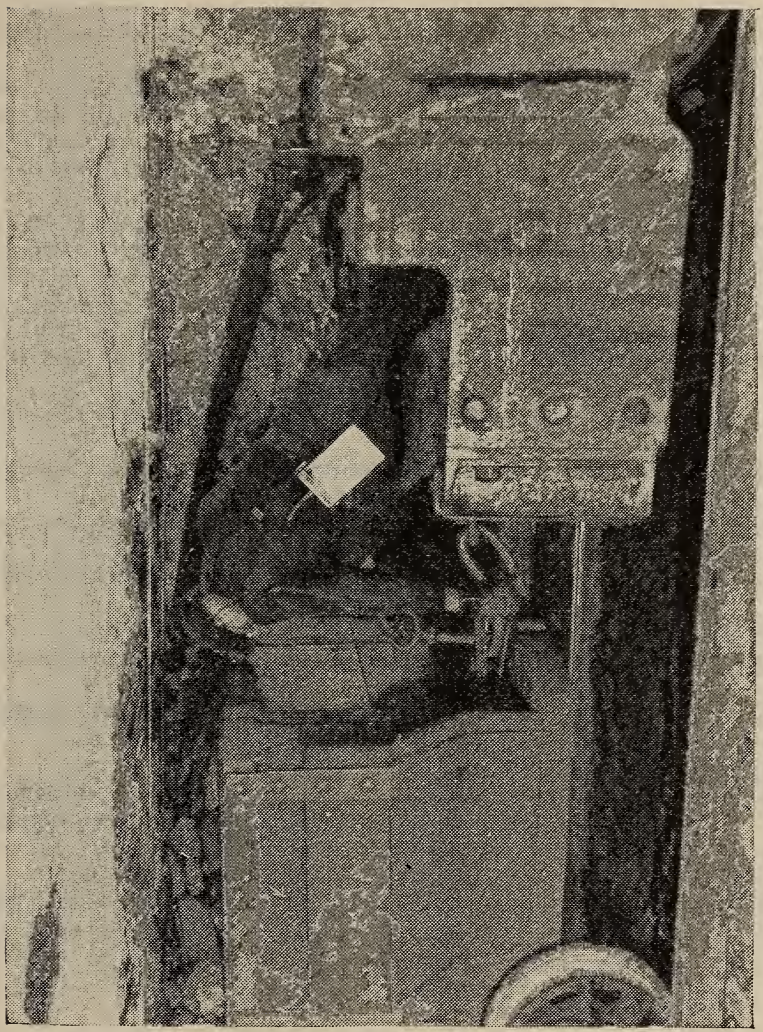

FIGURE 24.—The locomotive should be brought to a full stop before it is coupled to a car or trip.

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78. Q. *What precautions should be taken in making up trips to haul rail, pipe, or long supplies?*
A. One or more empty cars should be placed between the locomotive and the material, and no one should be permitted to ride on or in any of the cars.
79. Q. *What precautions should be observed before motormen leave locomotives?*
A. Reverse levers should be on neutral and brakes set.
80. Q. *What are the specific duties of motormen and brakemen relative to ventilating doors?*
A. They should not damage, block, or permit ventilating doors to remain open.
81. Q. *What is the duty of the motorman relative to spotting cars near a door or curtain?*
A. Cars or other equipment should not be spotted near or in doors or curtains.
82. Q. *What is the duty of the motorman relative to unsafe places along the haulageway?*
A. He should report such places to the mine foreman immediately.
83. Q. *What main precaution should be observed while cars are being delivered to the working face?*
A. All men should be in the clear.
84. Q. *How should a loaded trip be operated when a man car is in the trip?*
A. Under complete control and at a speed not to exceed 6 miles per hour.
85. Q. *Why should back-poling be prohibited?*
A. The trolley may leave the wire and strike an obstruction, causing the pole to break and hit the motorman, resulting in serious injury.
86. Q. *For safety, how should mine cars be maintained?*
A. So that no sharp projections exist, that cars are tight to prevent spillage, and that wheels are kept in proper running condition.

87. Q. *How high should cars be cribbed?*
A. Cars should *never* be cribbed to the height of roof, timber, doors, or trolley guards, or to such an extent that coal may be dislodged from the cars.
88. Q. *What devices should be used to rerail cars or locomotives?*
A. An effective rerailer that will permit the car or locomotive to be pulled back onto the rails, or a good lifting jack and blocks. (*See* fig. 25.)
89. Q. *What form of illumination should be provided for each animal or team used in the mines?*
A. A light on the front animal.
90. Q. *At what maximum speed should man trips be operated?*
A. Not more than 6 miles per hour.
91. Q. *When should man trips not be operated on long, steep grades?*
A. When other trips, which may get out of control, are on the grade above them.
92. Q. *Who should supervise the operation of man trips?*
A. The foremen.
93. Q. *What method should never be used in operating man trips?*
A. Man trips should *never* be pushed.
94. Q. *What type of cars should not be used in man trips?*
A. Drop-bottom cars should *never* be used.
95. Q. *How many cars are required for man trips?*
A. There should be enough cars to allow all men to ride inside of the cars on one side only without crowding.
96. Q. *When should men never get on a man trip?*
A. When it is in motion and when it is not attached to a locomotive or securely blocked.
97. Q. *When should men unload from a man trip?*
A. After it has come to a complete stop.
98. Q. *Where should men be required to wait for the man trip.*

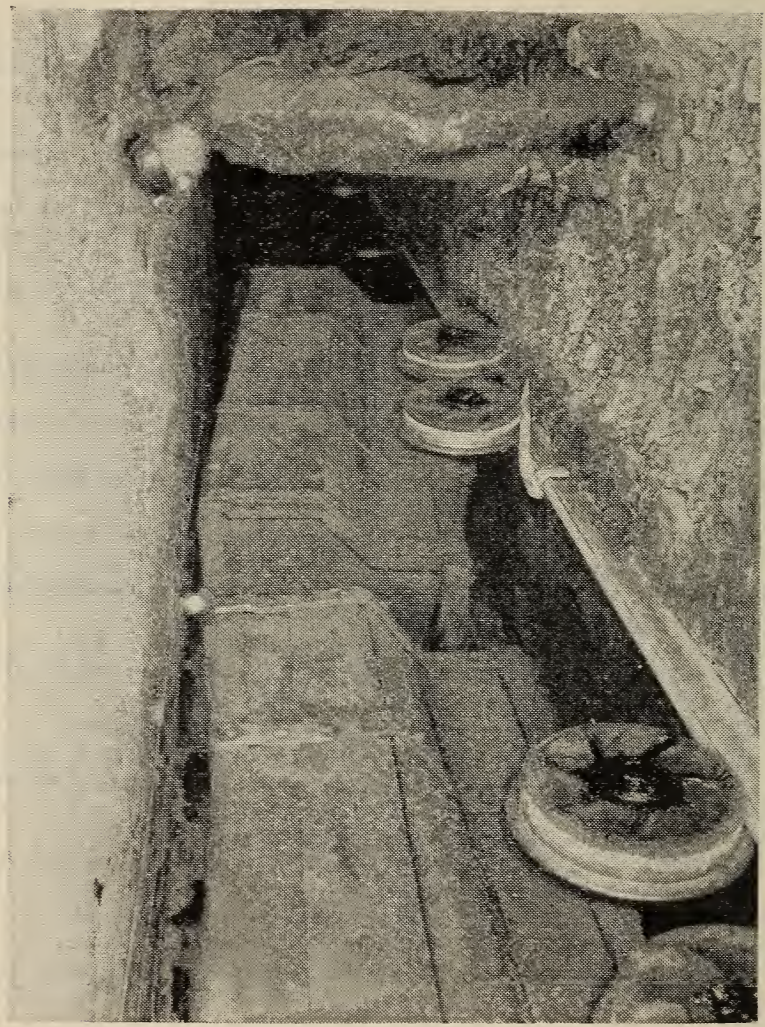

FIGURE 25.—Rerailers should always be used in rerailing cars on the haulage road.

A. A suitable place in a crosscut or other excavation off the haulage road should be provided at junction points where men congregate while waiting for the man trip.

99. Q. *How should tools be carried on a man trip?*
A. A car should be provided for tools, and tools should not be carried in cars with men.

100. Q. *What are the duties of motormen and trip riders relative to persons riding on locomotives or loaded cars?*
A. They should permit no one to ride on the locomotive or on loaded cars.

101. Q. *On which side of man-trip cars should men not be permitted to ride?*
A. On the trolley-wire side.

102. Q. *Where should men not get on or off cars?*
A. On the trolley-wire side, except where protection and clearance are maintained.

103. Q. *Why should men not attempt to cross moving trips?*
A. Because of the danger of falling between the cars and getting run over.

104. Q. *From what part of moving cars should men not get on or off?*
A. Men should not be permitted to get on or off *any* part of moving cars.

PREVENTION OF GAS AND DUST EXPLOSIONS AND MINE FIRES

TYPICAL EXAMPLES OF GAS AND DUST EXPLOSIONS

1. A shot firer was blasting coal with black blasting powder (pellet powder) at the face of an entry in a mechanical mine that was not rock-dusted. The shot hole was partly on the solid, and the working place, as well as the mine, was dry and dusty. The shot of black powder raised and ignited a

dust cloud, and the explosion was propagated throughout one section of the mine by coal dust; 72 men were killed as a result of this explosion.

The initial explosion would have been prevented by the use of permissible explosives charged and fired in a permissible manner, plus adequate watering practices in the face region. Propagation throughout the section would have been prevented by the application of rock dust to all surfaces in entries, rooms, and airways.

2. A trolley locomotive was shifting cars at the intersection of two haulage entries in a current of air that had passed through old abandoned workings and active working places before it reached the point where the ignition occurred. Suddenly, a large fall in one of the active working places released a large quantity of explosive gas; the gas was carried by the ventilating current to the open-type, trolley locomotive, where it was ignited. The resulting explosion killed 8 men by burns and afterdamp and 55 men by asphyxiation.

The operation of trolley locomotives and the installation of trolley wires and other bare power wires should be confined strictly to pure intake air.

3. A permissible mining machine and a permissible electric drill were in operation at the face of a working place in a gassy mine. Several holes had been drilled, a cut had been made in a new crosscut at the face, and the machine was preparing to sump in to cut the face. Both machines were in operation when an accumulation of gas, which had been liberated by the cutting and drilling, was ignited. The resulting gas explosion created a cloud of coal dust, which exploded and propagated the explosion throughout the entire section of the mine; 31 men were killed by the explosion. Both the permissible mining machine and the permissible electric drill were defective, with bolts missing from their protective cover plates; either piece of equipment could have ignited the gas.

Electrical equipment, permissible or otherwise, should not be operated in the presence of explosive gas; therefore, tests for gas

should be made before electrical equipment is started and frequently during its operation. Enough air should be conducted continuously to the face of all working places to dilute and carry away any methane that may be liberated.

4. A gas explosion occurred near the face of a pair of entries where a mine transitman and his helper were working. The explosion traveled outby about 1,000 feet; it also traveled into a pair of entries turned off to the right about 100 feet from the face. In addition to the engineer and his helper, seven men working on a conveyor unit were killed. It was found that the ventilation was not being conducted to the faces of the entries in which the ignition occurred and the air was short-circuiting through the second crosscut back from the face. Burned matches were found near the transit after the explosion; the engineer probably had attempted to smoke and ignited the gas. The mine was classed as nongassy by the State authorities, and smoking was not prohibited.

Every coal mine is a potentially gassy mine. Although this mine had operated for about 40 years and no gas ever had been reported, the occurrence of this explosion and the fact that gas was found after it indicate that any so-called nongassy mine can liberate gas, and the same precautions that are taken in gassy mines should be practiced in nongassy mines.

5. A member of a conveyor crew was drilling shot holes at the face of a crosscut turned off from the face of the entry. A grading crew was engaged in taking up bottom along the entry at a point inby the last open crosscut. Members of the grading crew raised and fastened up the line brattice leading to the face so that they could throw rock into the gob; this caused a short circuit of the air and permitted explosive gas to accumulate at the face. A small accumulation of gas was ignited by the open-type electric drill. The explosion of methane raised a cloud of dust from a slack pile at the face and ignited it; the explosion was propagated to the conveyor loading point in the entry, where more dust was picked up by

the explosion. The explosion eventually was stopped by rock dust before it got out of the section. Three men were killed, two died later as a result of burns and shock, and several others were affected by burns and afterdamp.

Here again the need for a continuous supply of fresh air to the working faces is indicated, and even seemingly minor interruptions frequently cause trouble. As a second line of defense against possible ignitions, all sources of arcs, sparks, and flame should be kept away from the working faces. The use of permissible electrical equipment instead of open-type equipment will prevent occurrences of this kind.

QUESTIONS AND ANSWERS

1. Q. *What are some of the common causes of coal-mine explosions?*
   A. The common causes of coal-mine explosions are (1) electricity, (2) open lights and smoking, and (3) explosives. During the 12-year period 1929 to 1940, electricity was responsible for 40.6 percent of the explosions, open lights and smoking were responsible for 36.4 percent, explosives were responsible for 15.2 percent, and unknown and miscellaneous causes were responsible for 7.8 percent. The greatly increased use of electricity in mining, with the necessary increase in the amount of wiring, trailing cable, and other accessories, has materially augmented the explosion hazard from this source.
2. Q. *What is the explosion record in the United States?*
   A. During the 5-year period 1906 to 1910, an average of 438 men was killed annually by explosions; during the 5-year period 1931 to 1935, an average of 65 men killed annually; and during the 5-year period 1936 to 1940, an average of 116 men killed annually. The high average during the last period was due to the large number (290) killed during 1940, which

equaled the total number killed during the preceding 4 years. The general trend in both frequency and severity of explosions since 1906 has been downward.

3. Q. *What States experience the most explosions?*
   A. For the 12-year period 1929 to 1940, Pennsylvania had the greatest number of explosions (88, with 220 deaths) and West Virginia, with 56 explosions, the greatest number of deaths—248. Ohio, with only 11 explosions, had the second largest number of of deaths. During this period, there was an average of 25.7 explosions and 111.5 deaths a year, with an average of 4.34 deaths per explosion.
4. Q. *What percentage of the total number of deaths of underground coal miners in 1939 and in 1940 was due to gas and dust explosions?*
   A. 4.5 percent in 1939 and 23 percent in 1940.
5. Q. *What combination of circumstances is necessary to initiate an explosion?*
   A. First, there must be fuel in the form of gas (methane) or coal dust to form an explosive mixture; then there must be a source of ignition, such as flame from an open light, match, or explosives or an electric arc. The elements that contribute to an explosion are present in most coal mines, but in many mines the combination of circumstances necessary to initiate one occurs rather infrequently when the number of mines in operation is considered.

PROPERTIES OF MINE GASES

AIR

6. Q. *What is air?*
   A. The mixture of gases surrounding the earth, forming the atmosphere.

7. Q. *What are the constituents of pure, dry air?*
   A. Oxygen (O_2), 20.93 percent; nitrogen (N_2), 78.10 percent; carbon dioxide (CO_2), 0.3 percent; and argon (A) and other rare gases, 0.94 percent.
8. Q. *What are the essential functions of air?*
   A. To support life and combustion.
9. Q. *What is considered pure intake air in mines?*
   A. Pure intake air is considered to mean (*a*) air that has not passed through or by any active workings; (*b*) air that has not passed through or by any inactive workings, unless these are effectively sealed; and (*c*) air that is free from poisonous gas and by analysis contains not less than 20 percent oxygen (dry basis) and not over 0.05 percent inflammable gas.
10. Q. *What is a dangerous or injurious atmosphere?*
    A. One that contains a harmful amount of poisonous gas, a dangerous amount of inflammable gas, or less than 20 percent oxygen.
11. Q. *Where is dangerous or injurious air most likely to be found in mines?*
    A. In unventilated abandoned areas or idle working places.
12. Q. *What precautions should be observed before a workman is sent into an abandoned or idle place?*
    A. The foreman should first examine the ventilation, test for gases, and observe the roof conditions.
13. Q. *What is a respirable atmosphere?*
    A. One suitable to sustain life.
14. Q. *What is an irrespirable atmosphere?*
    A. One unsuitable to sustain life.
15. Q. *What is meant by the term "humidity"?*
    A. The degree to which air is saturated with moisture.
16. Q. *What effect does temperature have on the amount of moisture that can be absorbed by air?*
    A. The capacity to absorb moisture increases as the temperature of the air increases.

17. Q. *What is the effect of high temperature and high humidity upon workers?*
    A. They make it increasingly difficult to do work.
18. Q. *What effect does a low outside temperature (below 60° F.) have upon the humidity of a mine?*
    A. As the intake air rises in temperature, it absorbs moisture and tends to dry the mine.
19. Q. *What effect does a high outside temperature (above 60° F.) have upon the humidity of the mine.*
    A. As the intake air cools, the ability to retain moisture decreases, and moisture is deposited in the mine.
20. Q. *What other changes occur to air used to ventilate a mine?*
    A. It may mix with methane, carbon dioxide, or other gas, lose oxygen by absorption or combustion, and either absorb or deposit moisture.
21. Q. *What is meant by the diffusion of gases?*
    A. The mixing of gases when they come in contact with each other.
22. Q. *Will diffused gases separate from a mixture because of their differences in weight?*
    A. No; they will not separate or stratify once they have been diffused or mixed.
23. Q. *Which is the easier to remove, a body of methane or carbon dioxide?*
    A. Methane would be easier to remove, as it is lighter than carbon dioxide and diffuses more readily with air.

OXYGEN

24. Q. *What element in air is essential to life?*
    A. Oxygen.
25. Q. *What is oxygen?*
    A. It is a tasteless, odorless, and colorless gas that supports life and combustion.

26. Q. *How does the body receive oxygen?*
    A. In the act of breathing, the oxygen of the air is taken up by the hemoglobin of the blood and carried to all parts of the body.
27. Q. *What chemical change does oxygen undergo in the support of life?*
    A. The oxygen combines with the carbon in the body to form carbon dioxide (CO_2).
28. Q. *What is blackdamp?*
    A. An atmosphere deficient in oxygen.
29. Q. *What is the lowest percentage of oxygen that will support the flame of a safety lamp?*
    A. Approximately 16 percent.
30. Q. *What is the lowest percentage of oxygen that will support the flame of a carbide lamp?*
    A. Approximately 12.5 percent.
31. Q. *Why cannot canaries be used to detect a deficiency in oxygen?*
    A. A canary can survive in an atmosphere containing less oxygen than is needed by man.

METHANE

32. Q. *What is methane* (CH_4)?
    A. A colorless, odorless, and tasteless combustible gas.
33. Q. *What is the source of methane in coal mines?*
    A. It is liberated from coal and adjoining strata.
34. Q. *Where is methane found?*
    A. In almost all coal mines.
35. Q. *What is the composition of methane?*
    A. Carbon and hydrogen (CH_4).
36. Q. *What is the specific gravity of methane?*
    A. The specific gravity of methane is 0.555 or slightly more than one-half the weight of air.

37. Q. *Where is methane usually found in mines?*
A. Along the roof, to the rises, in the vicinity of working faces, and above falls.
38. Q. *Why is methane not explosible by itself?*
A. Oxygen is required to support combustion.
39. Q. *What is firedamp?*
A. An explosive mixture of methane and air.
40. Q. *What is the range of explosibility for methane?*
A. Between 5 percent and 15 percent.
41. Q. *Why can there be no explosion when the percentage of methane is less than 5 percent?*
A. Because the heat liberated by combustion is dissipated into surrounding air rapidly enough to prevent flame propagation.
42. Q. *Why can there be no explosion when the percentage of methane is greater than 15 percent?*
A. Because not enough oxygen is present for rapid combustion.
43. Q. *What percentage of methane is required for maximum explosive violence?*
A. 10 percent.
44. Q. *What is the percentage of oxygen below which no explosion of a methane-air mixture can occur?*
A. 12 percent.
45. Q. *What is the effect of the presence of methane on the explosibility of coal dust?*
A. Coal dust is more easily ignited and the force of the explosion is greater.
46. Q. *What is the effect of coal dust in the air upon the explosibility of methane?*
A. The lower explosive limit is decreased. An explosion can occur in dusty air even if there is less than 5 percent of methane present.
47. Q. *How can methane be detected?*
A. By a flame safety lamp, by the use of methane detectors and testers, and by analysis. (See fig. 26.)

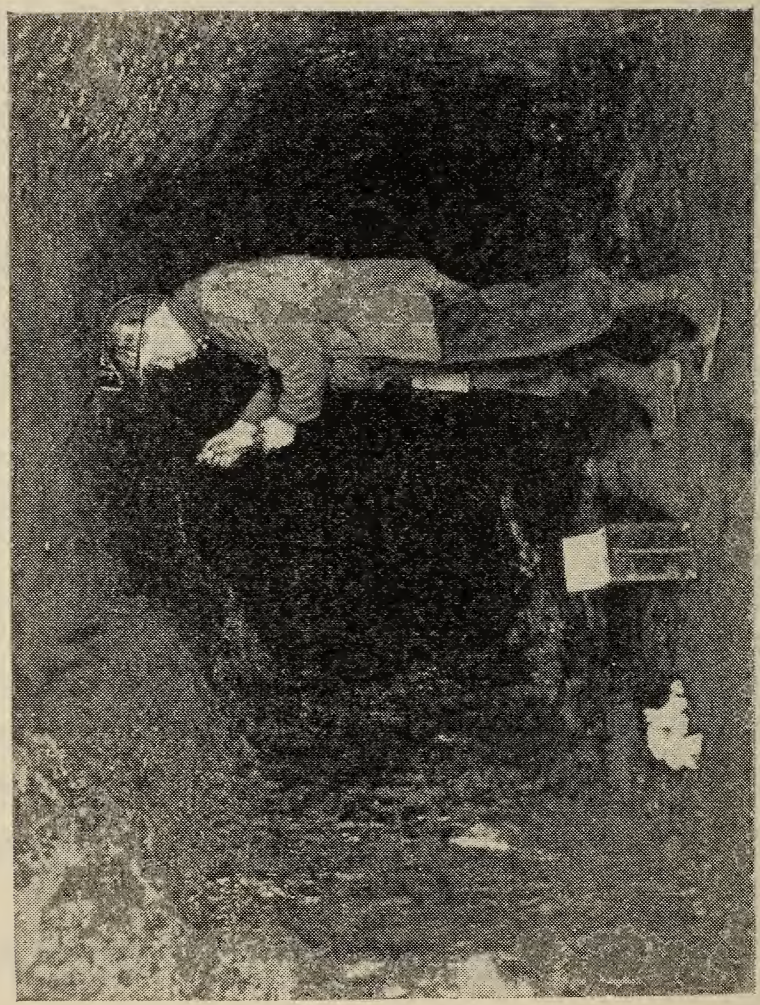

FIGURE 26.—An air sample is collected in the return airway by means of a vacuum bottle. The sample is analyzed later in the laboratory.

48. Q. *What dangerous gas is most likely to be encountered above a pillar fall?*
    A. Methane.
49. Q. *How large a body of methane is necessary to start a coal-dust explosion?*
    A. Tests [5] at the Experimental mine of the Bureau of Mines show that under most favorable conditions as to diffusion of gas, point of ignition, and placement of coal dust, a thoroughly diffused gas-air mixture of 146 cubic feet, containing approximately 13 cubic feet of methane, if ignited is sufficient to initiate a general explosion.

CARBON DIOXIDE

50. Q. *What is carbon dioxide* (CO_2)*?*
    A. Carbon dioxide is a colorless and odorless gas formed by the chemical combination of carbon and oxygen.
51. Q. *How is carbon dioxide formed in a mine?*
    A. By combustion, by breathing of men and animals, by decay of vegetable and animal matter, by the oxidation of coal, and by chemical action of acid water on carbonates.
52. Q. *What gas is the product of complete combustion?*
    A. Carbon dioxide.
53. Q. *What is the specific gravity of carbon dioxide?*
    A. The specific gravity of carbon dioxide is 1.529, or slightly more than one and one-half times the weight of air.
54. Q. *Is carbon dioxide combustible?*
    A. No; it is incombustible.

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[5] Although the conditions under which these tests were carried out are rarely found in commercial coal mines, results clearly indicate the danger of igniting even a small quantity of methane in the presence of coal dust.

55. Q. *Where would concentrated accumulations of carbon dioxide be found?*
    A. Near the floor, in dip workings, or in poorly ventilated places.
56. Q. *What effect does carbon dioxide have upon the body?*
    A. Lung ventilation is increased as carbon dioxide increases. When 5 percent of carbon dioxide is present, lung ventilation increases 300 percent, breathing is difficult, and continued exposure would be injurious. Ten percent of carbon dioxide could not be endured for more than a few minutes—collapse and death would follow.
57. Q. *How is carbon dioxide detected?*
    A. Usually by chemical analysis.

CARBON MONOXIDE

58. Q. *What is carbon monoxide* (CO)*?*
    A. It is a colorless, odorless, tasteless, combustible, and poisonous gas.
59. Q. *How can carbon monoxide be detected?*
    A. By carbon monoxide detectors, by canaries, and by air analysis. (*See* fig. 27.)
60. Q. *What is the source of carbon monoxide?*
    A. It is the product of incomplete combustion (combustion with insufficient oxygen).
61. Q. *When is carbon monoxide most likely to be found in mines?*
    A. When there is a mine fire or after an explosion.
62. Q. *What is afterdamp?*
    A. The atmosphere following a mine explosion or fire, containing carbon dioxide, carbon monoxide, decreased oxygen, nitrogen, hydrogen, and smoke.
63. Q. *What kinds of engines produce carbon monoxide?*
    A. Internal-combustion engines.

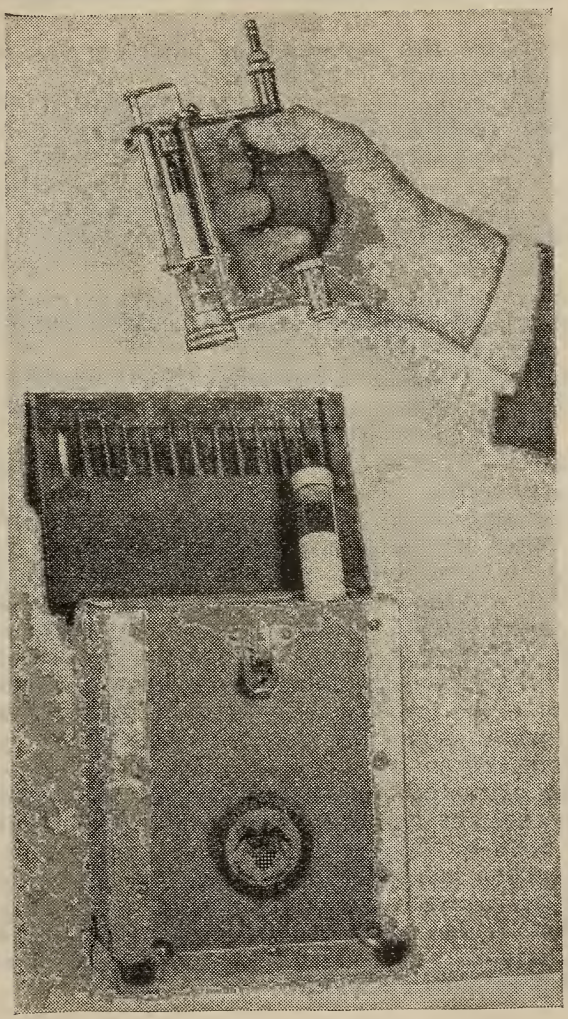

FIGURE 27.—The iodine pentoxide carbon monoxide detector is used in mine rescue and recovery operations.

64. Q. *What are the principal poisonous gases produced by explosives?*
A. Carbon monoxide and oxides of nitrogen.
65. Q. *What effect does carbon monoxide have on the body?*
A. It is extremely poisonous.
66. Q. *How does carbon monoxide cause injury to the body?*
A. By combining with the blood and excluding oxygen.
67. Q. *What percentage of carbon monoxide will produce symptoms in several hours?*
A. Two hundredths of 1 percent (0.02 percent).
68. Q. *What percentage of carbon monoxide will produce discomfort in 2 or 3 hours?*
A. Four hundredths of 1 percent (0.04 percent).
69. Q. *What percentage of carbon monoxide will produce a tendency to stagger in 1½ hours?*
A. Eight to twelve hundredths of 1 percent (0.08 to 0.12 percent).
70. Q. *What percentage of carbon monoxide will produce symptoms of unconsciousness in 30 minutes?*
A. Two to three tenths percent (0.2 to 0.3 percent).
71. Q. *What would be the effect of breathing one-half of 1 percent (0.5 percent) or more of carbon monoxide?*
A. The effect might be so sudden that a man would have little or no warning before he would collapse.
72. Q. *How much greater affinity does hemoglobin have for carbon monoxide than for oxygen?*
A. About 300 times.
73. Q. *Why are small quantities of carbon monoxide injurious?*
A. Because the gas is not easily thrown off, and accumulates in the blood.
74. Q. *Is carbon monoxide explosive?*
A. Yes; it is explosive over a wide range.
75. Q. *What is the most dangerous feature of carbon monoxide?*
A. Its poisonous character.

NITROGEN

76. Q. *What is nitrogen?*
A. It is a tasteless, odorless, and colorless gas that will support neither life nor combustion.
77. Q. *Is nitrogen combustible?*
A. No; it is incombustible.
78. Q. *What effect does nitrogen have toward propagating an explosion?*
A. None.
79. Q. *What effect does nitrogen have upon life?*
A. It has no effect, except when it replaces oxygen to such an extent that there is a deficiency of oxygen.

HYDROGEN SULFIDE

80. Q. *What is hydrogen sulfide?*
A. It is a poisonous, combustible, colorless gas having a sweetish taste and an odor like rotten eggs.
81. Q. *What mine gas can be detected by its odor?*
A. Hydrogen sulfide.
82. Q. *What is the origin of hydrogen sulfide?*
A. It is usually the product of the decomposition of sulfur compounds. (NOTE.—Burning of black powder, action of acid water on metallic sulfides, heating of sulfides in presence of moisture.)
83. Q. *How can hydrogen sulfide be detected other than by sense of smell?*
A. By the hydrogen sulfide detector or by paper dipped in acetate of lead, which will turn black immediately on exposure to hydrogen sulfide.
84. Q. *What is the range of explosibility of hydrogen sulfide?*
A. 4.3 percent to 46 percent.
85. Q. *Is hydrogen sulfide poisonous?*
A. Yes; even small amounts are extremely poisonous.

86. Q. *What percentage of hydrogen sulfide will cause death if breathed for some time?*
A. 0.05 percent.
87. Q. *What is the immediate effect of hydrogen sulfide on a person?*
A. It is extremely irritating to the nostrils and eyes.

NITROGEN PEROXIDE

88. Q. *What is nitrogen peroxide* (NO_2)*?*
A. It is an extremely poisonous gas frequently formed by the burning of high explosives.
89. Q. *Is nitrogen peroxide combustible?*
A. No; it is incombustible.
90. Q. *What percentage of nitrogen peroxide will be fatal?*
A. Extremely low concentrations, probably about 0.01 percent.
91. Q. *What are the first effects of nitrogen peroxide on a person?*
A. It is extremely irritating to the nostrils and eyes.
92. Q. *What is the particular danger of nitrogen peroxide?*
A. Its delayed action. Relatively small quantities may cause death even after apparent recovery.

SULFUR DIOXIDE

93. Q. *What is sulfur dioxide* (SO_2)*?*
A. A colorless, suffocating, irritating poisonous gas.
94. Q. *How is sulfur dioxide formed in a mine?*
A. By burning coal containing pyrites or by the firing of black powder.
95. Q. *What is the particular danger of sulfur dioxide?*
A. Small amounts are extremely poisonous.
96. Q. *What percentage of sulfur dioxide will result fatally?*
A. 0.05 percent.
97. Q. *How is sulfur dioxide detected?*
A. By the sense of smell and its effect on the air passages.

98. Q. *What is the first effect on a person exposed to sulfur dioxide?*
A. Sulfur dioxide is extremely irritating and suffocating and is intolerable to breathe.
99. Q. *Is sulfur dioxide combustible?*
A. No; it is incombustible.

HYDROGEN

100. Q. *What is hydrogen (H_2)?*
A. It is a colorless, odorless, tasteless gas.
101. Q. *How is hydrogen formed in a mine?*
A. It is formed by mine fires, explosions, and charging storage batteries.
102. Q. *Is hydrogen explosive?*
A. Yes; it is explosive over a wide range.
103. Q. *What is the explosive range of hydrogen?*
A. From 4.1 percent to 74 percent.
104. Q. *How is hydrogen detected?*
A. By chemical analysis.

COAL DUST

105. Q. *Is it possible to have an explosion in a mine without explosive gas being present?*
A. Yes. In addition to explosive gas, the fine coal dust deposited on the floor, ribs, roof, and timbers is explosive.
106. Q. *What usually causes explosions to spread over a wide area and sometimes extend throughout the mine?*
A. Coal dust.
107. Q. *Is all coal dust explosive?*
A. All bituminous-coal dust and lignite dust is explosive; anthracite dust is not explosive.
108. Q. *What coal dusts are most easy to ignite?*
A. The higher-volatile coal dusts are easier to ignite.

109. Q. *What mining operations produce dust?*
A. Cutting, drilling, blasting, loading, transportation, and dumping operations produce dust.
110. Q. *How is the fine coal dust distributed throughout the mine?*
A. It is picked up by the ventilating current and deposited on the ribs, roof, floor, and timbers.
111. Q. *How does coal dust contribute to the severity of an explosion?*
A. By being raised in clouds and ignited; the explosion is thus propagated through the mine.
112. Q. *Where is the greatest danger of an explosion of coal dust?*
A. Wherever coal dust is permitted to accumulate and a source of ignition is present.
113. Q. *When is it possible to have an explosion in a coal mine with no methane present?*
A. When quantities of coal dust are raised in a sufficiently dense cloud in the presence of a source of ignition.
114. Q. *What are the most prolific causes of coal-dust explosions?*
A. Explosions of methane, electric arcs, and explosives.
115. Q. *What quantity of explosive gas can start a dust explosion in an entry with a sectional area of 60 square feet?*
A. About 150 cubic feet.
116. Q. *How much coal dust is enough to propagate a coal-dust explosion?*
A. About one-twelfth ounce per cubic foot of air.
117. Q. *What are the largest-size particles of coal dust that will start an explosion?*
A. Any particle of coal dust that will pass through a 20-mesh screen.
118. Q. *What effect does fineness of coal dust have upon its explosibility?*
A. Fineness will increase the explosibility.

119. Q. *Will damp coal dust explode?*
A. Yes. (Dampness causes the dust particles to cohere, and greater force is required to separate them and bring them into suspension. Once in suspension, however, if ignited by a flame or an electric arc, they will explode.)

PREVENTION OF COAL-DUST EXPLOSIONS

120. Q. *How can the explosibility of coal dust be reduced?*
A. By the addition of incombustible material.
121. Q. *Does the use of water in the average mine lessen the hazard of ignition of coal dust?*
A. Only when used systematically and frequently to allay fine dust. (*See* fig. 28.)
122. Q. *What is the principal explosion hazard in tipples and cleaning plants?*
A. Accumulations of coal dust.
123. Q. *What should be the condition of tipples and cleaning plants relative to coal dust?*
A. They should be kept reasonably free from coal dust.
124. Q. *What should be done with accumulations of fine, dry coal dust in a mine?*
A. They should be removed from the mine.
125. Q. *How should dry and dusty operating sections be treated?*
A. They should be thoroughly watered or rock-dusted.
126. Q. *What benefit is derived from rock-dusting?*
A. By decreasing the explosibility of the mine-dust mixture, the danger of a coal-dust explosion is reduced.
127. Q. *What kinds of rock dusts should be used?*
A. Dusts with a low free silica content that will not absorb excessive amounts of moisture from the air.

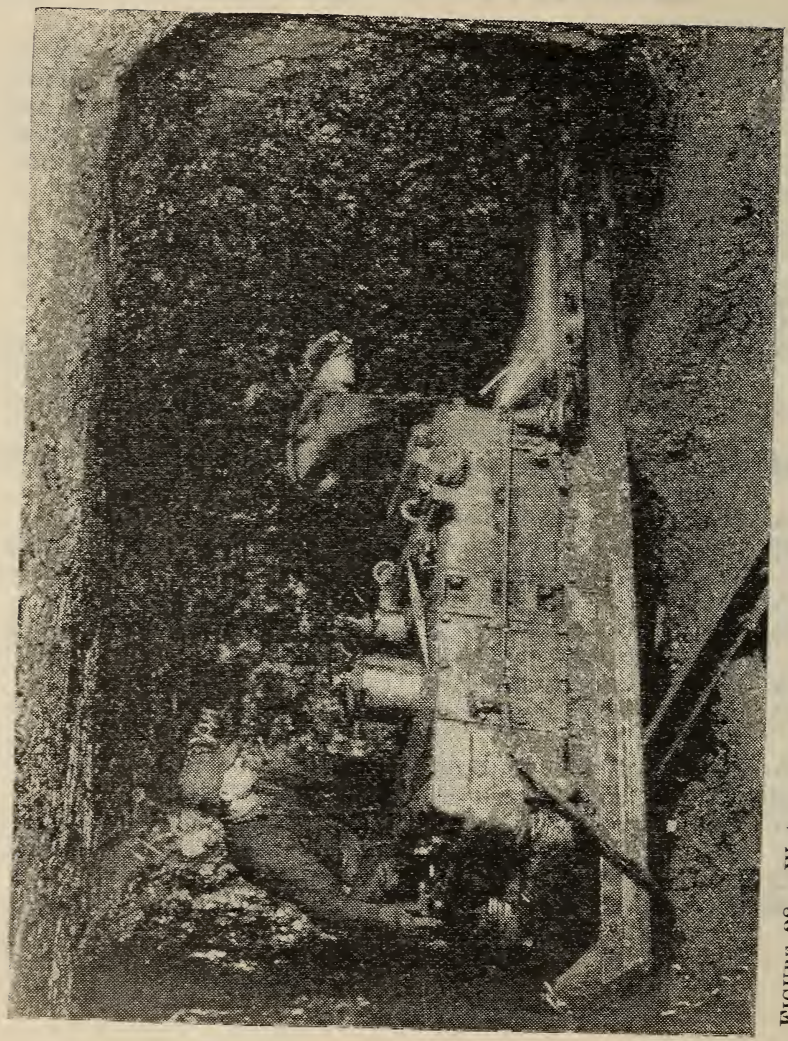

FIGURE 28.—Water on the cutter bar of mining machines reduces dustiness in face regions and helps to prevent coal-dust explosions.

128. Q. *What parts of a mine should be rock-dusted?*
A. All entries, aircourses, rooms, and pillar workings to the working face. (*See* fig. 29.)
129. Q. *How close to the working face should rock dust be applied?*
A. Within 40 feet of the face. (*See* fig. 29.)
130. Q. *What should be done before fine coal dust is loaded from haulageways?*
A. Water, calcium chloride, or other dust-allaying materials should be applied.
131. Q. *How should unusual quantities of coal dust be kept out of suspension?*
A. By sprinkling or other dust-allaying devices. (*See* figs. 30, 31, 32, and 33.)
132. Q. *After rock dust has been applied in a coal mine, how may the incombustible content of the mine be determined?*
A. By collecting samples of dust from sides, roof, and floor and analyzing them for total incombustible with a device known as a "volumeter," or by proximate analysis.
133. Q. *What is the minimum amount of incombustible material necessary to render coal dust nonexplosive?*
A. 65 percent.
134. Q. *What effect does the presence of small amounts of methane have upon explosibility of coal dust?*
A. It increases explosibility.
135. Q. *What effect does volatile matter in coal have upon its explosibility?*
A. Increase in volatile matter tends to increase the explosibility of coal.

PREVENTION OF GAS EXPLOSIONS

136. Q. *Where is every mine owner or operator required to employ a fireboss or firebosses?*

FIGURE 29.—Rock dust is applied to roof, ribs, floor, and timbers by a rock-dusting machine. The workmen wear dust respirators. The motor travels against the ventilating current to protect workmen from breathing dust.

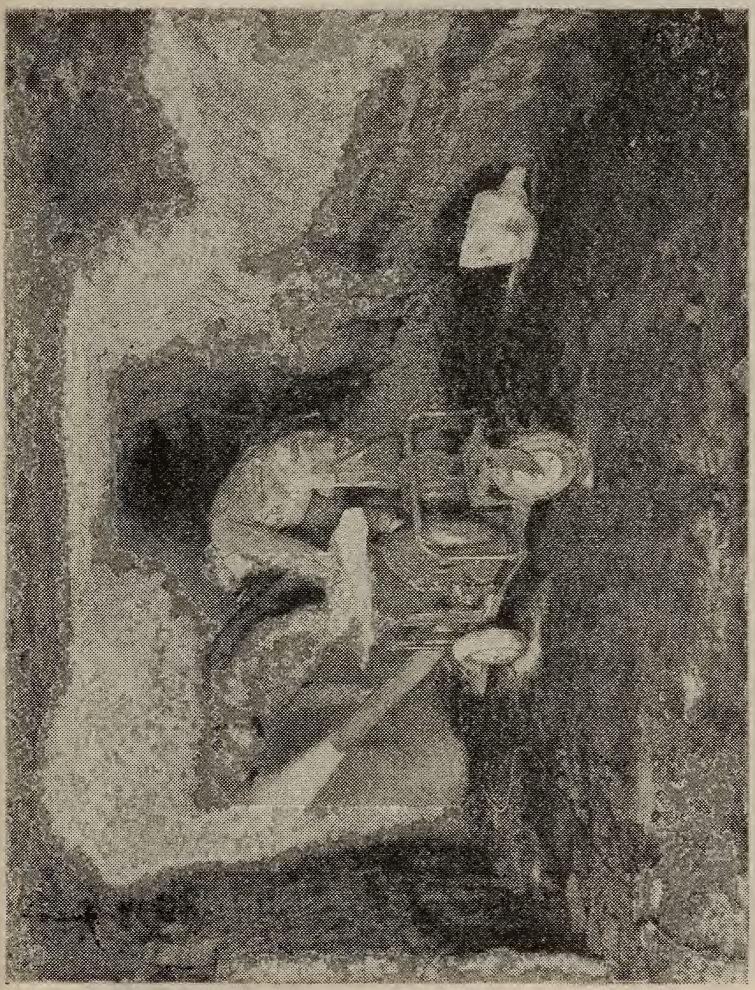

FIGURE 30.—A small, portable rock-dusting machine on rubber-tired wheels has been developed for rock-dusting trackless entries.

FIGURE 31.—After the coal has been blasted, the coal pile should be wet down thoroughly with water before the coal is loaded. This will help to control dust in face regions.

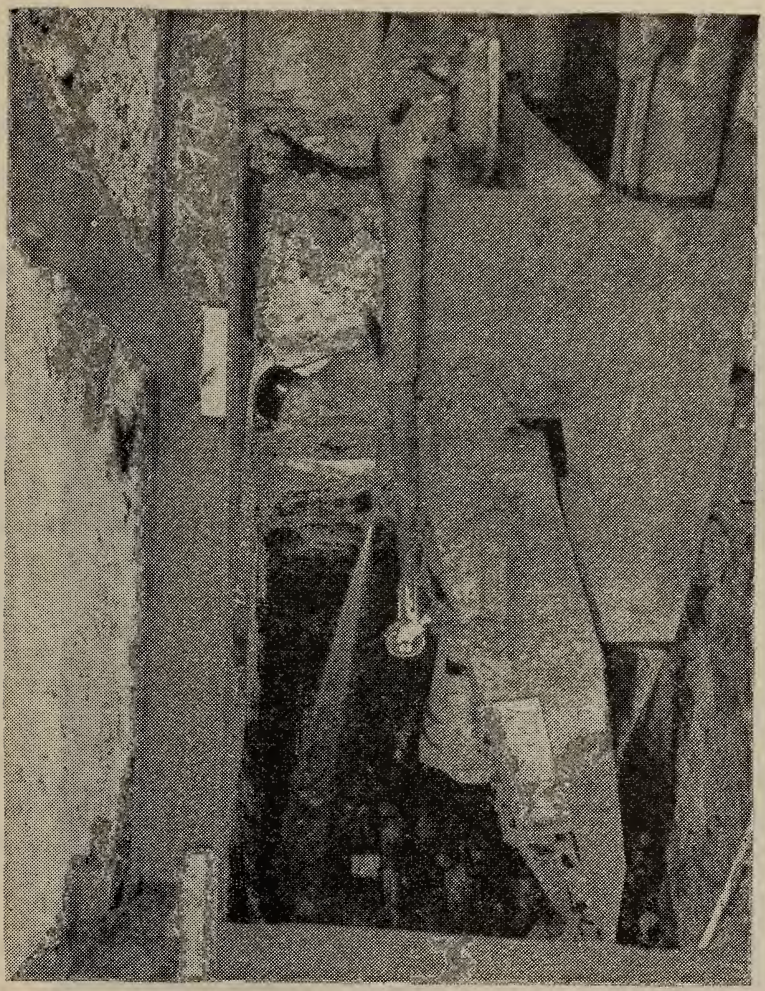

FIGURE 32.—Water should be applied to the broken coal as it is being loaded with the loading machine.

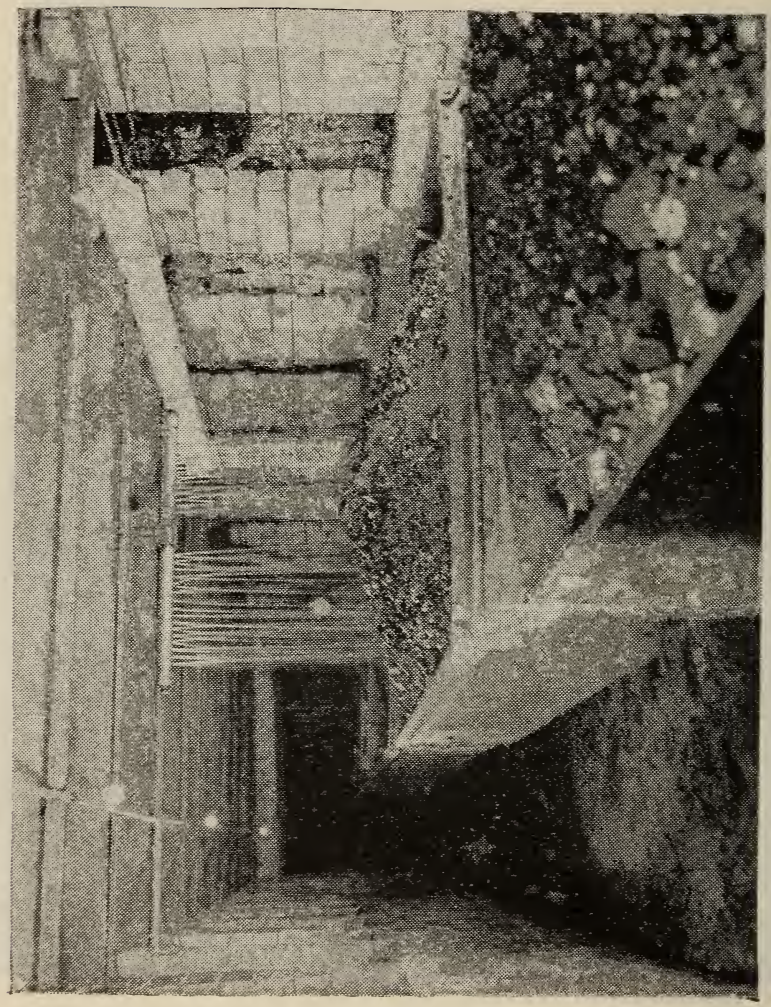

FIGURE 33.—Loaded cars of coal should be sprayed with water to reduce dustiness of haulage roads.

A. In "gassy" mines or where gases, other than methane, are likely to appear in working places or haulageways in quantities detrimental to the health or safety of the employees.

137. Q. *When should a mine be classed as "gassy"?*
A. Any coal mine wherein methane or other combustible gas can be detected in amounts of as much as 0.25 of 1 percent or more by frequent systematic searches shall be classified as a gassy mine.

138. Q. *When is a mine classed as "nongassy"?*
A. When no methane can be detected in a shot hole, in a crevice, or in the air.

139. Q. *What should be established at the entrance to each firebossed section of a mine?*
A. A fireboss station.

140. Q. *How should a fireboss station be marked before an examination has been made?*
A. By a red danger signal.

141. Q. *When should men not be permitted to enter a gassy mine?*
A. Before it is reported safe.

142. Q. *When should the danger signal at the entrance of a mine be removed?*
A. When the mine, or parts thereof, are reported safe.

143. Q. *Under what conditions should men be permitted to enter a mine for work before it has been found to be safe?*
A. When ordered by the management to make the mine safe and then only under the direct supervision of a mine official.

144. Q. *What instrument for gas detection should be carried by mine foremen and firebosses in all mines?*
A. Permissible flame safety lamp. (*See* fig. 34.)

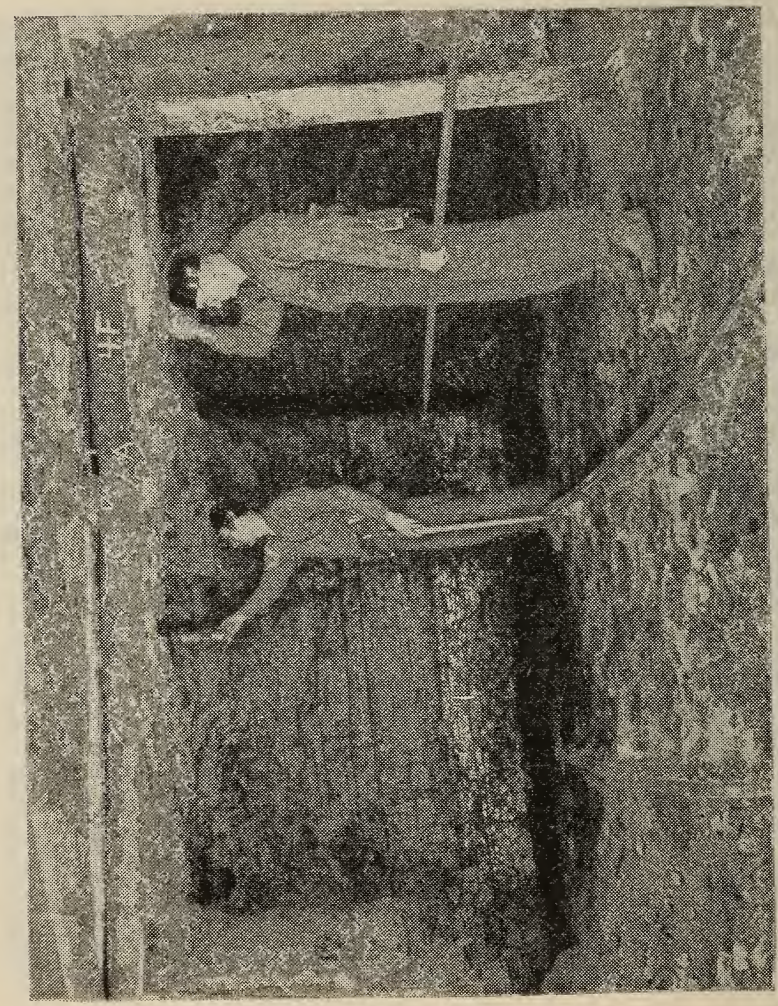

FIGURE 34.—The flame safety lamp is commonly used to detect explosive gas and oxygen deficiency in coal mines.

145. Q. *What instrument should be carried by mine foremen and assistants in mines where unusual quantities of black damp are likely to be found?*
A. Permissible flame safety lamp.
146. Q. *What type of locks should be used on flame safety lamps?*
A. Magnetic locks should be used.
147. Q. *If a flame safety lamp becomes extinguished, what procedure should be followed in relighting it?*
A. The lamp should be taken to fresh air and relighted with the internal igniter.
148. Q. *What should be done with flame safety lamps before each shift?*
A. They should be cleaned, filled, examined, and tested by a competent person.
149. Q. *What should be done in gassy mines, or sections thereof, before each shift commences work?*
A. Fireboss examinations should be made.
150. Q. *Where should a mine be examined for methane by all foremen and assistants?*
A. In all working places and adjacent idle places known to or likely to liberate gas.
151. Q. *When should foremen (or assistants) carry lighted flame safety lamps and test for gas?*
A. At all times while making their official inspections of the mine.
152. Q. *Where, other than in active working sections, should a gassy mine be regularly examined for gas?*
A. In entrances to old or abandoned workings.
153. Q. *How frequently should working pillar lines be examined for gas in addition to the regular fireboss run?*
A. At least every 2 hours.
154. Q. *When should working places be examined for gas?*
A. Within 2 hours before work is begun and at least every 2 hours during the working shift.

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155. Q. *What should be done in sections on the intake side of a firebossed section before men are permitted to work in any section on the return side?*
A. The doors and line brattice should be examined within the preceding 8 hours or the section should be dangered off.
156. Q. *When should work cease in a firebossed section?*
A. After 8 hours have elapsed since a fireboss examination.
157. Q. *What should be done when gas is discovered?*
A. The men should be withdrawn from the affected area, the power should be cut off, and the gas should be removed.
158. Q. *Who should supervise the removal of unusual, dangerous quantities of methane?*
A. A certified mine official or the district or State mine inspector.
159. Q. *To whom should unusual accumulations of methane be reported?*
A. The district mine inspector.
160. Q. *What should be required in working places and roadways relative to standing gas?*
A. They should be kept free from standing gas.
161. Q. *What should be done with accumulations of gas in worked-out or abandoned portions of a mine?*
A. They should be removed as soon as possible, or the area should be effectively sealed.
162. Q. *How should dangerous gases be removed?*
A. They should be diluted with air, rendered harmless, and carried away by the ventilation.
163. Q. *What should be done before unusual, dangerous accumulations of gas are removed?*
A. Men should be withdrawn and power disconnected from all places on the return.
164. Q. *From what dangers is protection required in unused or abandoned parts of a mine?*
A. Dangers of accumulations or overflow of gas.

165. Q. *How should all unused and abandoned parts of the mine be protected against the accumulation or overflow of gas?*
A. By ventilation or by proper sealing.
166. Q. *What should be done with electric power when unusual, dangerous accumulations of methane are found in any portion of a mine?*
A. Electric power should be disconnected from the affected area.
167. Q. *What should be done with electric power in a section when ventilation fails?*
A. Electric power should be disconnected.
168. Q. *What should be done before power is restored to a section where ventilation has failed or accumulations of methane have been removed?*
A. The section should be thoroughly examined and pronounced safe.
169. Q. *Who should supervise the reopening of sealed areas?*
A. The State mine inspector.
170. Q. *What evidence is required that working places have been examined?*
A. The date of examination should be marked at the face. (*See* fig. 35.)
171. Q. *What is the first thing a miner should do upon entering his place at the beginning of a shift in a firebossed mine?*
A. See if the fireboss has placed a danger board.
172. Q. *What is the first thing a miner should do upon reaching the face of his place at the beginning of the shift in a firebossed mine?*
A. Look for the date placed by the fireboss.
173. Q. *What should a miner do when he fails to find the fireboss mark?*
A. Notify the foreman or section foreman.
174. Q. *What articles of everyday use are prohibited in a gassy mine?*

FIGURE 35.—A mine official should leave his initials and date mark at the face of each working place when he makes his examination.

A. Smoking material and unapproved devices for making lights.

175. Q. *What precaution should be taken to prevent unauthorized articles from being carried into a gassy mine?*

A. Every person entering the mine should be searched.

176. Q. *How often should men entering the mine be searched for prohibited articles?*

A. At least once a week.

177. Q. *What should be the qualifications of a person placed in charge of a cutting machine in a gassy portion of a mine?*

A. He should be competent to determine the safety of the place and detect explosive gas.

178. Q. *What physical requirement is essential for those competent to detect explosive gas?*

A. Their eyes should be in good condition or properly fitted with glasses.

179. Q. *What should be required before a cutting machine, loading machine, or electric drill is permitted to work beyond the last break-through in a gassy mine?*

A. The place should first be examined for gas and found to be safe. (*See* fig. 36.)

180. Q. *How long should a cutting machine be permitted to work in a gassy mine without an examination for gas?*

A. 15 minutes. If gas is found, the machine should not be operated until gas is removed.

181. Q. *What should be done upon the completion of a cut and before the machine is moved from places in which gas is likely to be detected?*

A. An examination should be made for gas, and if gas is found the machine should not be moved until the gas is removed.

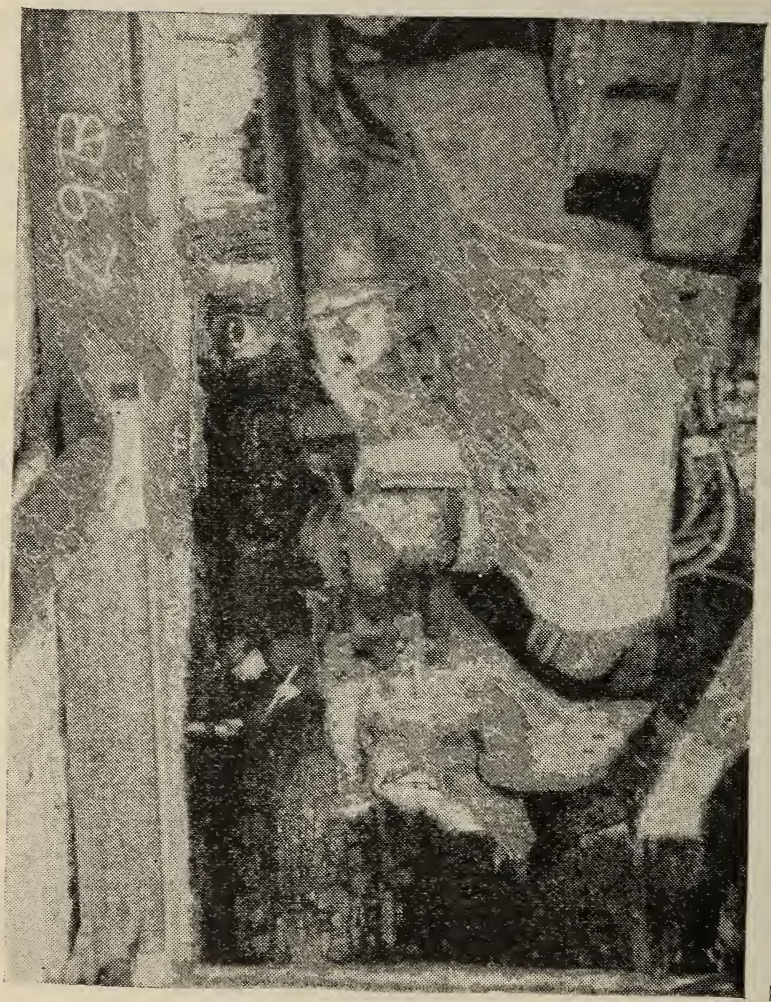

FIGURE 36.—The air should be tested frequently for explosive gas in places where electric equipment is in operation.

182. Q. *In what direction, relative to the air currents, should cutting be done in gassy mines?*
A. From the return and toward the intake.
183. Q. *What equipment should be provided with every cutting machine, loading machine, or electric drill in every gassy mine (unless accompanied by a certified man)?*
A. A flame safety lamp; the operators of this equipment should be able to test for gas.
184. Q. *What is required for the safekeeping of flame safety lamps furnished with a cutting machine?*
A. A protective box should be provided.
185. Q. *What is a machine runner required to do when gas is detected at a working face?*
A. Cut off the electric current and notify the mine foreman or fireboss.
186. Q. *What should be done before a cutting machine is permitted to be started after a place is reported unsafe?*
A. The danger should be removed, and the place should be examined and pronounced safe.

VENTILATION

187. Q. *What is the purpose of mine ventilation?*
A. To provide enough pure air to the employees and to dilute, render harmless, and carry away all dangerous and noxious gases.
188. Q. *How many openings are necessary to provide adequate ventilation?*
A. At least two.
189. Q. *What maximum number of men may be employed in a mine before ample ventilation is required?*
A. Ample ventilation should be provided in all mines where one or more men work.

190. Q. *How should mine ventilation be obtained?*
A. By the use of fans, mechanically operated.
191. Q. *When should a mine be ventilated?*
A. Continuously throughout its operating life.
192. Q. *Why should a mine be ventilated continuously?*
A. Stoppage of the ventilating current may allow dangerous or noxious gases to accumulate.
193. Q. *What should be the minimum amount of air passing the last break-through of an entry?*
A. 6,000 cubic feet per minute. NOTE.—See requirements in Coal-Mine Inspection Standards.
194. Q. *How should a mine be ventilated?*
A. By coursing the air through the intake airways to the working faces and returning it to the outside by the return airways.
195. Q. *What are the main requirements of an intake opening?*
A. That it be unobstructed, fireproof, and located away from possible sources of contamination to the air.
196. Q. *What are the main requirements of airways?*
A. That they are of sufficient area and kept free from obstructions.
197. Q. *How can adequate ventilation be best circulated?*
A. By a multiple-entry system.
198. Q. *What is a common fault of the double-entry system?*
A. Insufficient area and falls restrict the volume and increase the resistance, resulting in inefficiency.
199. Q. *How is the ventilating current controlled?*
A. By the use of break-throughs, stoppings, doors, overcasts, regulators, check curtains, and line brattices.
200. Q. *What are the main requirements of break-throughs?*
A. That they be kept open for persons to travel and be large enough in area to maintain adequate ventilation.
201. Q. *What portions of a mine should not be traversed by the air current before reaching working places?*
A. Abandoned workings not regularly inspected.

202. Q. *What means should be used to insure ventilation at faces when break-throughs are driven more than 60 feet apart?*
A. Line brattice or other approved methods of ventilation should be used.
203. Q. *What means should be used to insure ventilation at faces where unusual quantities of gas or smoke may be present?*
A. Line brattice or other approved methods of ventilation should be used.
204. Q. *Why should idle dead-end places not be permitted?*
A. They cannot be ventilated continuously, and gas may accumulate.
205. Q. *How should rooms be ventilated?*
A. By means of check doors (or curtains).
206. Q. *Where should rooms* not *be opened?*
A. In advance of the ventilating current.
207. Q. *When men are discovered working in places in advance of air currents, what action should be taken?*
A. The men should be withdrawn immediately.
208. Q. *What attention should be given to the ventilating fan, airways, and travelways of a mine?*
A. A careful watch should be kept over them by the mine officials.
209. Q. *What action should be taken in case of accident or stoppage of the ventilating fan?*
A. The men should be ordered to withdraw from the mine immediately.
210. Q. *What action should be taken before men are permitted to return to a mine after an accident to or stoppage of the ventilating fan?*
A. Ventilation should be restored and the mine thoroughly ventilated, examined, and reported safe.
211. Q. *Who is authorized to examine a mine after an accident to or stoppage of the ventilating fan?*
A. The mine foreman, assistant foreman, or fireboss.

212. Q. *Should ventilation be shifted from idle sections to active sections on different shifts?*
A. No.
213. Q. *When should ventilation be changed?*
A. When the mine is idle.
214. Q. *How should stables be ventilated?*
A. By a separate split of air.
215. Q. *Where should the return from a stable be conveyed?*
A. Direct to the return current.
216. Q. *How should inside substations, transformer stations, and battery charging stations be ventilated?*
A. By a separate air current direct to the return.
217. Q. *Why should excessively high velocities in a mine be avoided?*
A. High velocities increase the necessary ventilating pressure, keep coal dust in suspension, and cause discomfort to the workers.
218. Q. *Why should extremely low velocities be avoided?*
A. Low velocities will not sweep out the gases properly.
219. Q. *How may high velocities be avoided?*
A. By using airways of adequate cross-sectional area and by splitting the air current.
220. Q. *For efficient ventilation, what should be the maximum velocity in airways?*
A. About 500 feet a minute.
221. Q. *What is meant by splitting a ventilating current?*
A. Dividing the main current into separate individual currents.
222. Q. *What is an air split?*
A. A portion of the main ventilating current forming a continuous current throughout a definite part of the mine.
223. Q. *What effect does splitting have on resistance to the flow of air?*
A. The mine resistance will be decreased.

224. Q. *What effect does a decrease in mine resistance have on performance of a fan?*
A. The fan is enabled to circulate an increased quantity of air with no increase in the ventilating pressure.
225. Q. *What are the two systems of fan ventilation?*
A. Blowing (force) and exhaust (suction).
226. Q. *How can the main haulageway of a mine be placed on fresh air when the mine is ventilated by a force system?*
A. By using air locks or by placing the haulageway on a separate split.
227. Q. *On what air current should haulage be placed?*
A. On the intake.
228. Q. *What are the advantages of having the main haulageway on the intake if an explosion occurs?*
A. Usually, access to the mine is more easily obtained without subjecting men to the hazards of gas and smoke; and a safe means of escape is provided for men in the mine.
229. Q. *What is the main disadvantage of having the intake near the dumping point?*
A. Dust from the dumping point frequently is carried into the mine.
230. Q. *What may be the disadvantage of having workers on the return in a gassy mine?*
A. The return may contain an explosive mixture of gas.
231. Q. *What are stoppings?*
A. Partitions erected across openings.
232. Q. *What is the purpose of a stopping?*
A. To prevent short-circuiting of the air or to seal off portions of the mine.
233. Q. *What is short-circuiting of the air?*
A. Permitting it to enter the return before reaching the faces.

234. Q. *What material is used to construct stoppings?*
A. Concrete, brick, tile, rock, slate, wood, and brattice cloth.

235. Q. *What kind of material should be used to construct stoppings along permanent haulage roads?*
A. Durable and incombustible material.

236. Q. *Why should wood and other perishable material be used for temporary stoppings only?*
A. They allow great leakage of the ventilating current and form a fire hazard.

237. Q. *What material should not be used to construct stoppings?*
A. Gob.

238. Q. *What is the principal requirement for stoppings?*
A. They should be airtight.

239. Q. *What is the economical effect of airtight stoppings?*
A. Costs are decreased by an increase in ventilating efficiency.

240. Q. *When and where should brattice-cloth stoppings be used?*
A. Only temporarily, in the next to the last open breakthrough.

241. Q. *How can the ventilation of large abandoned areas be avoided?*
A. By sealing them. (Open abandoned areas require ventilation, and frequently the oxygen supplied to such areas combines with carbonates to form CO_2 or may cause spontaneous combustion. Abandoned areas should be sealed effectively.)

242. Q. *How should stoppings be constructed to seal an abandoned area?*
A. They should be constructed substantially of incombustible material, with pipes inserted to prevent the building up of pressure inside the seal and to allow sampling of the inside atmosphere. (*See* fig. 37.) Water traps should be provided for drainage when necessary.

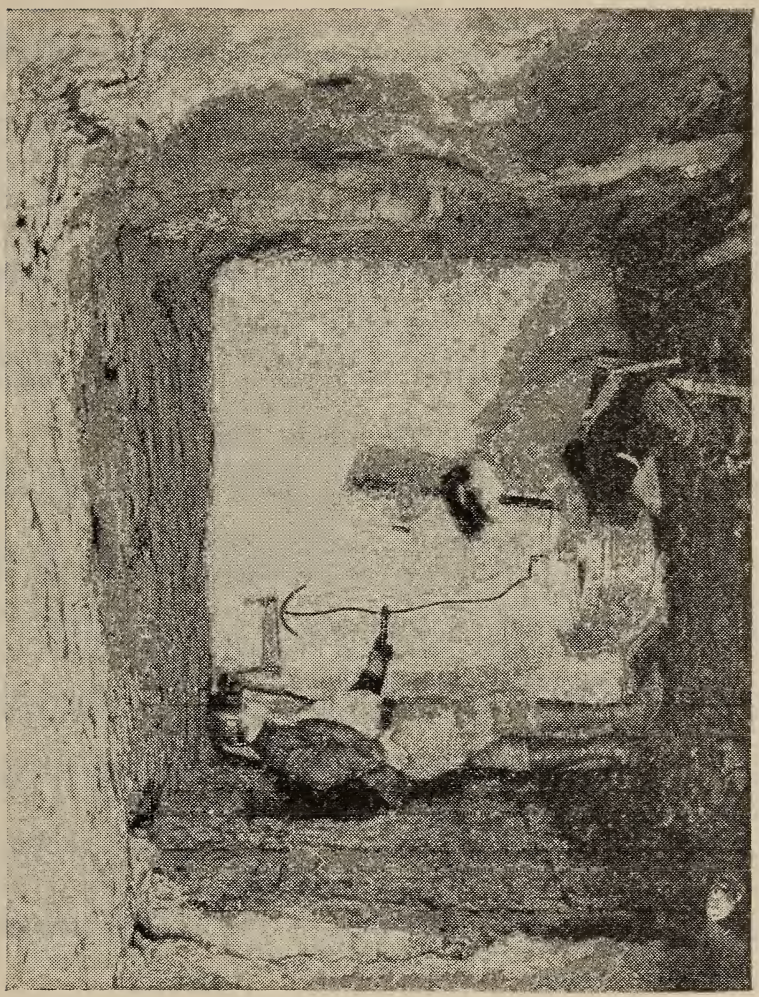

FIGURE 37.—Collecting a sample of air from behind a fire seal. The stopping has been provided with a water gage and breather pipe.

243. Q. *What is a line brattice?*
A. It is a curtain erected from the last break-through, along the entry, to the face.
244. Q. *What is the purpose of a line brattice?*
A. To conduct an air current to the working face with sufficient velocity to remove dangerous gases and smoke from explosives.
245. Q. *What materials are used for line brattices?*
A. Brattice cloth or wood.
246. Q. *When brattice cloth is used, what precautions should be taken against fire?*
A. The brattice cloth should be fire-resistant or noninflammable.
247. Q. *How should the space behind line brattice be maintained?*
A. Clean and open for the free flow of air.
248. Q. *What is an overcast?*
A. An enclosed airway that provides a means for one air current to cross another.
249. Q. *How should an overcast be constructed?*
A. It should be airtight and substantially constructed of incombustible material.
250. Q. *What are the main requirements of an overcast?*
A. To provide enough area for the air current and to allow a smooth, uninterrupted flow of air.
251. Q. *What are the results of some common errors in constructing overcasts?*
A. Rough and abrupt interruptions to the ventilating current and insufficient area.
252. Q. *How do overcasts aid haulage?*
A. They eliminate the necessity for doors on the haulage road.
253. Q. *How do overcasts aid ventilation?*
A. They allow frequent splitting of the air and provide for uninterrupted ventilation.

254. Q. *What is a regulator?*
A. An artificial obstruction in an airway with an opening that can be varied to change resistance to air flow.
255. Q. *What is the purpose of a regulator?*
A. To control the distribution of the air by regulating the resistance to flow.
256. Q. *How is a regulator usually constructed?*
A. It usually is a stopping provided with an opening having a sliding door.
257. Q. *What is the effect of a regulator on the quantity of air entering a split?*
A. The quantity is decreased.
258. Q. *Why are regulators essential to the ventilation of a mine?*
A. They proportion the air to meet the requirements of each individual split.
259. Q. *Who determines where regulators are placed?*
A. The mine foreman or other person in charge of ventilation.
260. Q. *What types of regulators are used?*
A. Box and door types.
261. Q. *Where are the regulators ordinarily placed in a mine?*
A. At the return ends of the splits having the least resistance.
262. Q. *What is the purpose of ventilating doors?*
A. To direct the course of the ventilation and permit traffic to pass.
263. Q. *Why are doors in a mine objectionable?*
A. If damaged or left open they allow short-circuiting of the air, permit leakage, and (unless built of incombustible material) constitute a fire hazard.
264. Q. *How should a door be hung?*
A. So that it will close automatically and tightly.

265. Q. *What provision should be made to prevent a short circuit of a main ventilating current controlled by doors?*
A. Doors should be hung in pairs to form air locks.
266. Q. *How far apart should the doors of an air lock be placed?*
A. They should be far enough apart to accommodate a full trip of cars without both doors being open at the same time.
267. Q. *When are doors advisable?*
A. Only where air locks can be made and where it is impracticable to use overcasts.
268. Q. *If a serious explosion of methane occurred in a normally well ventilated mine, what would be the most probable cause of the gas accumulation?*
A. A door being left open.
269. Q. *Is the use of automatic doors preferable to ordinary doors?*
A. Yes; but they should be inspected regularly and kept in good operating condition.
270. Q. *In what direction should doors swing to close?*
A. In the direction of flow of the air current.
271. Q. *With what device should doors be provided to permit observation of persons or trips on the other side?*
A. Small windows.
272. Q. *What facilities should be provided for the passage of persons through doors where ventilating pressure prevents easy opening?*
A. Man doors on the clearance side.
273. Q. *Under what condition should the installation of doors on main haulageways in gassy mines be avoided?*
A. Doors should be avoided on main haulageways wherever possible.
274. Q. *What are the requirements relative to the construction of doors on main haulageways?*

A. They should be built substantially, hung to close automatically, and installed in pairs.

275. Q. *What precaution should a foreman take at the end of each shift to assure a proper ventilation for his section?*

A. See that the doors on his section are closed.

276. Q. *What is the purpose of check curtains?*

A. To deflect the air current from entries into working faces.

277. Q. *Where should a curtain be used?*

A. Only within the limits of an active working section where leakage is not detrimental.

278. Q. *What better method may be used in checking the air into working places?*

A. Temporary doors.

279. Q. *What causes air to circulate through a mine?*

A. The difference in pressure between the intake and the return.

280. Q. *How is the difference in pressure between the intake and the return created?*

A. By difference in temperature or by mechanical means.

281. Q. *Why is natural ventilation not reliable?*

A. The direction varies with weather conditions; when the outside temperature approximates the inside temperature, movement of the air stops.

282. Q. *What is the most reliable means of producing ventilation in a mine?*

A. A mechanically operated fan. (*See* fig. 38.)

283. Q. *Where should mine ventilating fans be installed?*

A. Outside of the mine.

284. Q. *How should fan buildings be constructed?*

A. Of incombustible material.

285. Q. *Where should fans be installed with respect to mine openings?*

A. They should be placed to one side and connected to the opening by means of air ducts.

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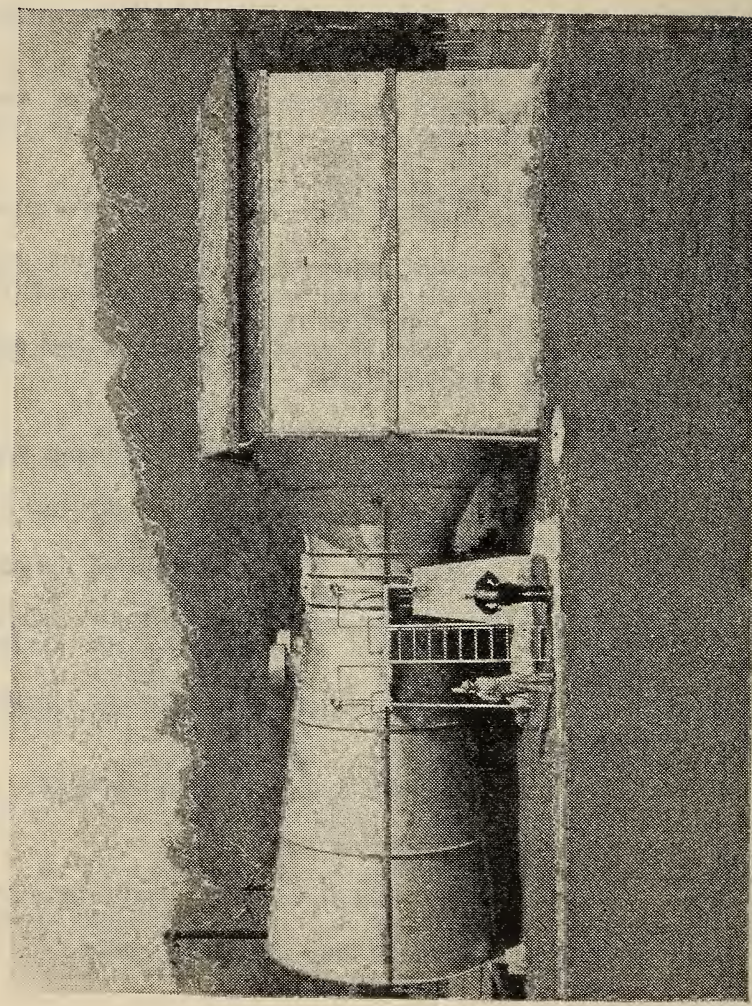

FIGURE 38.—Ventilating fans should be of adequate size and capacity to ventilate the mine properly.

286. Q. *Why should fans not be installed in a mine opening?*
A. Because of the possibility of their destruction by a mine explosion.

287. Q. *How can a mine-fan installation be protected from an explosion?*
A. By explosion doors, when placed to one side of an outlet.

288. Q. *What is the purpose of explosion doors?*
A. To relieve the pressure of an explosion before it reaches the fan.

289. Q. *Why should mine fans not be installed inside?*
A. Because of the fire hazard, no means of protection against explosions, and the possible recirculation of used air.

290. Q. *Are booster and blower fans advisable?*
A. No.

291. Q. *Why are booster and blower fans objectionable?*
A. Because they may recirculate the air, they constitute a fire hazard, and their intermittent use may permit accumulations of gas.

292. Q. *Why should mine fans be reversible?*
A. So that the air current can be reversed in case of fire or explosion, if deemed advisable.

293. Q. *How are mine fans made reversible?*
A. By an arrangement of air doors in the fan housing or in the mine, or by changing the direction of rotation of aeroplane-propeller and disk fans.

294. Q. *What arrangements should be made at the fan to insure uninterrupted ventilation?*
A. Emergency fans or auxiliary motors or engines should be provided.

295. Q. *For what period before a fireboss run in a gassy mine should the fan be operated at normal speed?*
A. 24 hours.

296. Q. *To whom should defects in ventilation observed by miners be reported?*
A. To the mine foreman.

SOURCES OF IGNITION

297. Q. *What are the principal sources of ignition of methane and coal dust in coal mines?*
A. Electric arcs and sparks, improper blasting practices, open lights, defective flame-safety lamps, matches, and smoking.

ELECTRIC ARCS AND SPARKS

298. Q. *What dangers are connected with electric circuits in mines?*
A. Electric shock hazard, and fires and explosions from short circuits.
299. Q. *What are some of the dangers created by operation of electric equipment in coal mines?*
A. Fires and explosions from overheated equipment and from unguarded flashes or arcs.
300. Q. *How may the danger of shock from bare wires be lessened?*
A. By placing them in the clear or guarding them where persons pass, and by the use of sectionalizing switches or circuit breakers to cut off the power.
301. Q. *What causes abnormal heating of wires and cables?*
A. Wires and cables too small, poor splices, poor connections, or low voltage.
302. Q. *How should trailing cables be protected against overheating?*
A. By using large enough cables and by properly fused trolley taps or junction boxes.
303. Q. *What is the danger from poorly made splices in a trailing cable?*
A. Poor splices may heat and may short-circuit, setting fire to the cable.
304. Q. *What is the result of poor rail bonding?*
A. Low voltage and arcs and sparks near working faces.

305. Q. *What are the hazards of poor rail bonding?*
A. Mine fires, explosions, electric shocks, and stray currents.
306. Q. *What kind of telephones should be provided in gassy mines?*
A. Permissible telephones.
307. Q. *What is the principal danger from inside substations?*
A. Mine fires.
308. Q. *How should an inside substation be constructed?*
A. It should be fireproof and equipped with automatically closing fire doors.
309. Q. *How can the danger of explosions from operating electric equipment be lessened?*
A. By replacing open-type electric equipment with permissible equipment and using it in a permissible manner.
310. Q. *What is meant by permissible electric equipment?*
A. Equipment similar in all respects to that approved by the Federal Bureau of Mines, after it has passed successfully the prescribed permissibility tests and inspections.
311. Q. *Under what conditions is an electrical device considered permissible?*
A. When all details of the device agree with that tested and meeting the requirements necessary for approval by the Federal Bureau of Mines.
312. Q. *When is an electrical device considered explosion-proof?*
A. When it is so constructed that any flames from an explosion within the device will be cooled to such an extent that they cannot reach the outside and ignite a surrounding explosive mixture.
313. Q. *How is a possible explosion in permissible equipment cooled before it reaches outside air?*
A. By cooling action of wide metal surfaces at the joints and bearings and by rapid expansion of combustion

products escaping through narrow openings at joints.

314. Q. *What is the maximum separation of a joint tolerated for permissibility?*
A. 0.004 inch.

315. Q. *What width of metal in contact is required in a joint to make it permissible?*
A. Generally 1 inch.

316. Q. *What kinds of gaskets are permitted between joints in permissible equipment?*
A. None; there should be metal-to-metal contact, except where glass is used in headlights and meter cases.

317. Q. *What is necessary to establish the identity of permissible equipment?*
A. Federal Bureau of Mines approval plate.

318. Q. *How is the permissibility of equipment commonly destroyed?*
A. By improper maintenance.

319. Q. *What is the effect of dust and dirt between the joints of permissible equipment?*
A. Permissibility is destroyed when the joint cannot be closed tightly enough to provide the required cooling action.

320. Q. *What is meant by flameproof electric equipment?*
A. Flameproof equipment usually has a wire gauze to cool flames escaping from the interior.

321. Q. *Why is flameproof electric equipment not permissible?*
A. The general construction is not adequate to meet the requirements for permissibility.

322. Q. *What is meant by enclosed electric equipment?*
A. Equipment designed to exclude dust.

323. Q. *Why is enclosed electric equipment not permissible?*
A. The construction will not confine flame.

324. Q. *Why can no permissible plates be obtained for cable-reel and trolley locomotives?*

A. Because of the open spark from the trolley and the possibility of sparks or arcs at the wheels or from a damaged cable.

325. Q. *Why is operation of cable-reel and trolley locomotives considered to be more hazardous than operation of a mining machine?*

A. The hazard from sparks or arcs from the wheels or cable is greater.

326. Q. *What are the dangers from open-type storage-battery equipment?*

A. Dangerous fires may occur from short-circuiting, and the exposed sparking in motors and controls may ignite gas.

327. Q. *Under what conditions should permissible electrical equipment be used in gassy mines?*

A. Permissible electrical equipment only should be operated in any gassy mine except on pure intake air.

328. Q. *What method of haulage should be used for gathering coal in face regions?*

A. Animal haulage or permissible storage-battery locomotives.

329. Q. *How can electric arcs and sparks be eliminated from working faces?*

A. By exclusive use of permissible electrical equipment at working faces and by proper maintenance of track and other parts of electrical circuits.

330. Q. *How should permissible electrical equipment be attached to the power source?*

A. By using fused nips when it is connected to the trolley or feeder wire in pure intake air or by using permissible junction boxes when it is connected to the feeder circuit in other than pure intake air.

331. Q. *Under what conditions will permissible electrical equipment not afford protection against gas ignitions?*

A. When it is not properly maintained or when it is not operated in accordance with the caution statement on the approval plate.

332. Q. *Can permissible electrical equipment be operated safely in an explosive mixture of firedamp?*

A. Permissible electrical equipment properly maintained will give protection against gas ignitions; however, it should not be operated in any place where enough methane is present to be detected with a flame safety lamp.

333. Q. *What should an operator of a permissible electrical machine do at the beginning of each shift?*

A. He should inspect the machine personally to see: (1) That there are no open holes into the motor or any other electrical parts, (2) that all cover plates and all bolts and other fastenings of electrical parts are in place and properly secured, (3) that the machine wiring and trailing cable are in good condition, (4) that the trolley tap contains the proper size of fuse (unless connection is made to a permissible junction box or equivalent), and (5) that the machine is cleaned of coal dust, oil, and grease.

334. Q. *What action should the operator of a permissible electrical machine take when the machine does not appear to be in permissible condition?*

A. He should report the condition to the mine foreman or repair foreman immediately, and he should not operate the machine until the defect is remedied.

EXPLOSIVES

335. Q. *What is black blasting powder?*

A. A comparatively slow explosive consisting of a mixture of sodium nitrate with sulfur and charcoal.

336. Q. *How is granular black powder usually packed?*

A. In 25-pound-capacity metal kegs.

337. Q. *How is black powder fired?*
A. By spark or flame.
338. Q. *How is black powder classed as to its permissibility?*
A. As nonpermissible.
339. Q. *What type of flame is produced when black powder is fired?*
A. A flame of large volume and long duration.
340. Q. *What is the danger of a flame of large volume and long duration?*
A. It will ignite coal dust or an explosive mixture of firedamp.
341. Q. *What dangerous gases are formed when black powder is fired?*
A. Carbon monoxide and hydrogen sulfide.
342. Q. *What are the dangers from the use of black powder in coal mines?*
A. Fires, premature explosions, gas and dust explosions, and poisonous gases.
343. Q. *What is pellet powder?*
A. It is a compacted black powder, designed for convenient handling.
344. Q. *How is pellet powder prepared?*
A. In cylinders or pellets 2 inches long with a central perforation, and wrapped with paraffin paper in sticks.
345. Q. *How is pellet powder classed as to permissibility?*
A. As nonpermissible.
346. Q. *What dangerous gases are formed when pellet powder is fired?*
A. Carbon monoxide and hydrogen sulfide.
347. Q. *Should black blasting or pellet powder be used in coal mines?*
A. No; they have caused many serious explosions.
348. Q. *What is dynamite?*
A. It is a high explosive with a nitroglycerin base.

349. Q. *What is the action of dynamite as compared with black or pellet powder?*
A. It is much more rapid in action, and the total volume of gas released is greater.
350. Q. *How is dynamite fired?*
A. By shock or detonation.
351. Q. *How does the type of flame produced by firing dynamite compare with that produced by black powder?*
A. It is not as large or of as long duration.
352. Q. *How is dynamite classed as to permissibility?*
A. As nonpermissible.
353. Q. *What is the principal danger from the use of dynamite in coal mines?*
A. The violence and heat of detonation may create a dust or gas explosion.
354. Q. *What permissible explosive is designed for rock-blasting?*
A. Gelatin permissible explosives.
355. Q. *What dangerous gas is formed when dynamite is exploded?*
A. Carbon monoxide.
356. Q. *What poisonous gas other than carbon monoxide is liberated when dynamite burns instead of exploding?*
A. Oxides of nitrogen.
357. Q. *Should dynamite be used in coal mines?*
A. No.
358. Q. *What is a permissible explosive?*
A. One that has passed certain tests conducted by the Bureau of Mines.
359. Q. *For what purpose are permissible explosives designed?*
A. For safe use in gassy or dusty mines.
360. Q. *What agency passes upon the permissibility of an explosive?*
A. The Federal Bureau of Mines.

361. Q. *What characteristics of the flame determine the permissibility of an explosive?*
A. Short flame of short duration.
362. Q. *What maximum volume of poisonous gases determines the permissibility of an explosive?*
A. The volume of poisonous gases must not be greater than 5½ cubic feet per 1½-pound charge.
363. Q. *Besides the characteristics of their ingredients, what other requirements determine the permissibility of an explosive?*
A. The conditions under which it is used.
364. Q. *To remain permissible, what must be the physical condition of a permissible explosive?*
A. It must be in first-class condition when used.
365. Q. *What will cause permissible explosive to deteriorate?*
A. Moisture and improper storage.
366. Q. *To remain permissible, how must a permissible explosive be fired?*
A. By an electric detonator cap of not less strength than a No. 6.
367. Q. *To remain permissible, what kind of blasting unit must be used to fire permissible explosives?*
A. A permissible blasting unit.
368. Q. *To remain permissible, what is the maximum charge of permissible explosives for one hole?*
A. 1½ pounds.
369. Q. *To remain permissible, how must permissible explosives be stemmed?*
A. They must be properly confined in a borehole with incombustible stemming material.
370. Q. *What must be the condition of the working place before permissible explosives can be fired in a permissible manner?*
A. There must be no dangerous accumulations of firedamp.

371. Q. *How must the coal be prepared before permissible explosives can be fired in a permissible manner?*
A. The coal must be cut or sheared.
372. Q. *What may be the result of using permissible explosives in a nonpermissible manner?*
A. Any of the accidents that may occur from the use of other explosives are possible.
373. Q. *What is the effect of dampness upon permissible explosives?*
A. They deteriorate rapidly.
374. Q. *What is the relative safety of permissible explosives compared to that of black blasting powder?*
A. Black blasting powder is at least 70 times more likely to ignite gas than are permissible explosives.
375. Q. *What is the relative safety of permissible explosives compared to dynamite?*
A. Dynamite is at least 17 times more likely to ignite gas than are permissible explosives.
376. Q. *Has increased use of permissible explosives been followed by a decrease in accidents from explosives?*
A. Yes; decidedly so.
377. Q. *What is the principal cause of accidents from explosives when permissible explosives are used?*
A. Carelessness or improper usage.
378. Q. *What type of shot should not be fired in any mine?*
A. Adobe (mudcapped) shot.
379. Q. *What is the danger of firing an adobe (mudcapped) shot?*
A. The unconfined explosion will raise dust that may become ignited.
380. Q. *How should heavy boulders be blasted?*
A. By blockholing. A hole is drilled, the explosive is confined with stemming, and a pile of incombustible material is placed over the hole. (*See* fig. 39.)

FIGURE 39.—Mudcapped shots are dangerous. When boulders are blasted, holes are first drilled in them. Explosives should always be confined in boreholes when used underground.

381. Q. *What types of explosives should not be used inside mines?*
A. Dynamite, black powder, or pellet powder.
382. Q. *What kinds of explosives should be used in coal mines?*
A. Permissible explosives or other permissible blasting devices.
383. Q. *What is the danger of cushion shooting?*
A. Cushion shooting may not permit proper tamping, resulting in a blown-out shot.
384. Q. *What is the purpose of cutting the coal?*
A. To provide an additional free face or faces to assist the action of the explosive and lessen the danger of a blown-out shot.
385. Q. *What is the danger of shooting off the solid?*
A. Ignition of gas and coal dust by blown-out shots.
386. Q. *What should be the length of the drill hole?*
A. About 6 inches shorter than the cut.
387. Q. *What is the effect of too long a hole or one that grips the rib?*
A. The effect of the cut is partly lost, and a blown-out shot may be caused.
388. Q. *How should the hole be prepared before loading?*
A. It should be scraped clean.
389. Q. *How many kinds of explosives may be used in the same hole?*
A. One only.
390. Q. *How should all explosives be placed for shooting inside a mine?*
A. They should be confined in a drill hole with proper stemming.
391. Q. *What is proper stemming material?*
A. Incombustible material such as sand, clay, or rock dust. (*See* fig. 40.)

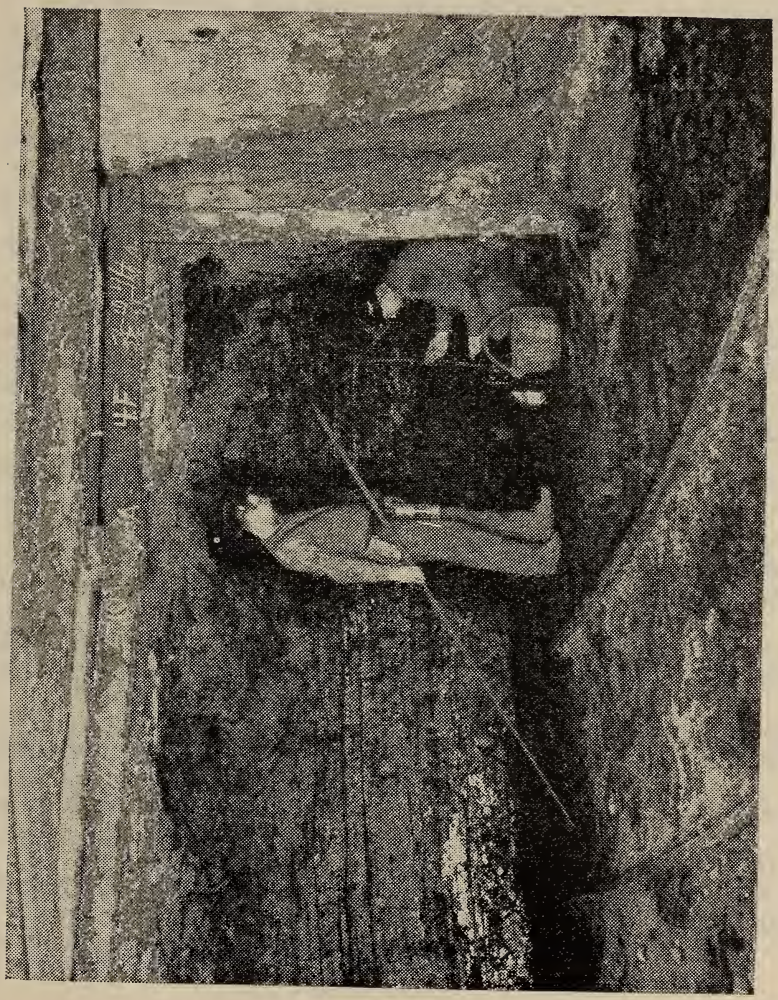

FIGURE 40.—Clay or other incombustible material is used for stemming.

392. Q. *Why is coal-dust stemming dangerous?*
A. The flame of the explosion will be increased, and the coal dust may be ignited.
393. Q. *What is the effect of incombustible stemming upon the flame of an explosion?*
A. The length and duration of the flame are decreased.
394. Q. *When is a drill hole properly stemmed?*
A. When it is tamped tightly from the explosive to the mouth of the hole with incombustible material.
395. Q. *What is the danger of improper stemming?*
A. The danger of a blown-out shot.
396. Q. *What may be the result of separation of the charge by unremoved drillings?*
A. Incomplete explosion and possible burning of the unexploded charge.
397. Q. *What is required before shots may be fired in a place known to liberate explosive gas?*
A. The place should be properly examined with a flame safety lamp.
398. Q. *When is the firing of a shot prohibited?*
A. When gas is detected.
399. Q. *What should be done to guard against a gas explosion when multiple shooting is done?*
A. A test should be made for gas before the shot is fired.
400. Q. *What is considered a dangerous percentage of methane when permissible explosives are to be fired?*
A. 1½ percent or more.
401. Q. *What is the danger of rapid shooting of subsequent shots?*
A. Gas liberated or dust raised by the first shot may be ignited by subsequent shots.
402. Q. *Who should be designated to fire shots?*
A. Only persons who can qualify as competent shot firers.
403. Q. *What is the danger from the use of fuse or miner's squib in a gassy mine?*

A. Sparking of the powder charge will ignite explosive mixtures.

404. Q. *What types of single-shot blasting units have been approved?*

A. Battery and magneto-type units.

405. Q. *What determines the permissibility of a single-shot blasting unit?*

A. The current must not be strong enough to ignite gas, and the unit must be provided with safety contacts.

406. Q. *What kind of firing devices should be used when multiple shooting is done?*

A. Permissible firing devices.

407. Q. *Why must shots not be fired from the trolley wire?*

A. High voltages may form arcs that will ignite gas.

408. Q. *How may ignitions of gas by explosives be prevented?*

A. By the exclusive use of permissible explosives and blasting devices, used in a permissible manner.

409. Q. *What action should a miner take if he observes that permisisble explosives are not being used in a permissible manner?*

A. He should report the condition to the mine foreman.

OPEN LIGHTS

410. Q. *Why is the use of open lights in coal mines dangerous?*

A. Open lights will ignite gas or coal dust; many explosions have been caused by open lights.

411. Q. *Should the use of open lights be prohibited in gassy mines only?*

A. No; open lights should not be permitted in any coal mine.

412. Q. *Give two reasons why open lights should not be permitted in a mine classed as nongassy.*

A. First, open lights will ignite coal dust and may cause a dust explosion; second, mines that are classed as

nongassy may be improperly classified or they may suddenly become gassy.

413. Q. *What kind of lights should be provided for the miners in coal mines?*
A. Permissible electric cap lamps.

414. Q. *What are the principal safety features of permissible electric cap lamps?*
A. The light source is enclosed in a headpiece provided with an automatic ejector that will break contact before an ignition of gas is possible should the bulb break. The battery case is magnetically locked.

415. Q. *Why is the use of permissible electric cap lamps desirable in all coal mines?*
A. Because the use of electric cap lamps removes one very prominent gas- and dust-ignition hazard from coal mines and provides better illumination.

416. Q. *Under what conditions is it safe to use a permissible electric-cap-lamp battery for firing shots?*
A. When the battery has been provided with a permissible blasting attachment.

417. Q. *What is commonly used to detect methane?*
A. A flame safety lamp.

418. Q. *What is a flame safety lamp?*
A. A lamp with the flame enclosed within wire gauze and a strong glass chimney.

419. Q. *What is the purpose of the gauze of a flame safety lamp?*
A. To cool the burning gases or flames of an explosion within the lamp and prevent them from igniting inflammable gases in the surrounding atmosphere.

420. Q. *How is methane detected with a flame safety lamp using a luminous (walking or traveling) flame?*
A. Methane causes elongation of the flame.

421. Q. *How is methane detected with a flame safety lamp with a nonluminous flame?*
A. Methane forms a pale blue cap over the flame.

422. Q. *Can a cap on a nonluminous flame be observed in the presence of light from a cap lamp?*
A. No; the pale blue cap becomes invisible in the presence of illumination from a cap lamp.
423. Q. *What is the minimum percentage of oxygen required to support the flame of a safety lamp?*
A. Approximately 16 percent.
424. Q. *What atmospheric conditions can be detected with a flame safety lamp?*
A. Deficiency of oxygen and the presence of methane.
425. Q. *What effect has deficiency of oxygen on a high flame?*
A. The height of flame will decrease, and the light intensity will diminish.
426. Q. *In the presence of oxygen deficiency and methane atmospheres, can methane be detected by the flame safety lamp?*
A. Yes; but only by observation of the height, color, and light intensity of the flame.
427. Q. *Does the extinguished flame of a safety lamp always denote deficiency of oxygen?*
A. No. Explosive mixtures will extinguish the flame and burn in the gauzes.
428. Q. *What precautions must be taken so that a flame safety lamp can be used safely?*
A. It must be clean, parts in good condition and assembled properly, and the fount correctly filled with good-grade fuel.
429. Q. *What are some of the errors likely to occur in assembling flame safety lamps?*
A. Leaving out or misplacing gaskets or expansion rings, failure to tighten properly, and using unclean or defective gauzes.
430. Q. *How can the hazards of relighting a safety lamp with matches be avoided?*
A. By using magnetically locked lamps.

431. Q. *Where does the air enter a safety lamp?*
A. Partly through the lower gauze ring and partly through the gauzes directly over the globe.
432. Q. *Under what conditions is it possible for a flame to pass through the gauze of a safety lamp and ignite a gas mixture?*
A. When the gauze is defective or unclean, when the lamp is in excessive velocities of air, and when the gauze is permitted to become too hot.
433. Q. *What fuel is best-suited for use in a safety lamp?*
A. High-grade gasoline (naphtha).
434. Q. *What is the lowest percentage of methane that can be detected readily with a flame safety lamp?*
A. About 1 percent.
435. Q. *What height of flame in a safety lamp is best-suited for testing in comparatively high percentages of methane?*
A. A nonluminous flame.
436. Q. *When is a safety lamp properly filled with fuel?*
A. When the cotton packing is thoroughly saturated and excess fuel is drained out.
437. Q. *To obtain best results, where should a safety lamp be held relative to the eyes when detecting gas with a nonluminous flame?*
A. It should be held a little above the eyes.
438. Q. *What is a permissible flame safety lamp?*
A. A lamp that is similar in all respects to one that has passed successfully a series of prescribed inspections and tests conducted by the Federal Bureau of Mines.
439. Q. *Is a key-locked flame safety lamp permissible?*
A. No; a permissible flame safety lamp must be magnetically locked.
440. Q. *When is a flame safety lamp not safe?*
A. When it has any defective parts or when it is improperly assembled.

441. Q. *Who should be responsible for the care and maintenance of electric cap lamps and flame safety lamps?*
A. A well-qualified and competent lamp-house attendant.
442. Q. *Is it proper to open a lamp for relighting in a coal mine?*
A. A flame safety lamp should never be opened after it has been taken underground. Many disastrous explosions have resulted from attempts to relight flame safety lamps with matches.

SMOKING

443. Q. *Why should all smoking in coal mines be prohibited?*
A. Because of the danger of gas ignitions and the possibility of starting mine fires.
444. Q. *What is the best way to guard against the possibility of men taking matches or smokers' supplies underground?*
A. By posting a warning at the entrance to the mine and by searching every man daily as he enters the mine.
445. Q. *What action should a miner take if he knows that a fellow worker or official is smoking underground?*
A. He should inform the mine foreman of whatever facts are in his possession.

MINE EXPLOSIONS AND RESCUE AND RECOVERY OPERATIONS

446. Q. *What are the principal causes of mine explosions?*
A. Ignition of gas or coal dust or both by electric arc, open lights, use of black powder, blown-out shots, and smoking. (*See* fig. 41.)
447. Q. *What is the most common source from which mine explosions are started?*
A. Accumulations of explosive mixtures of methane.
448. Q. *What is the principal cause of accumulations of explosive mixtures of methane?*
A. Interrupted ventilation.

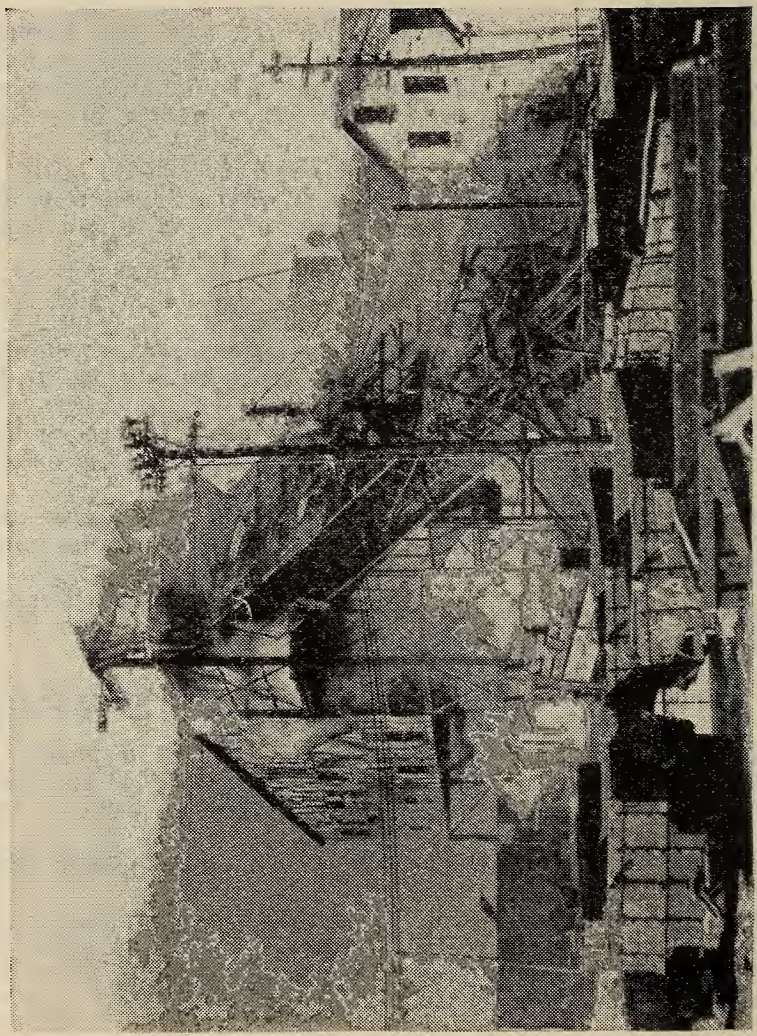

FIGURE 41.—An explosion in a Pennsylvania mine traveled to the outside and destroyed the coal tipple.

449. Q. *What is the most common cause of interrupted ventilation?*
A. Leaving doors open.
450. Q. *What negligent act constitutes the most dangerous explosion hazard in coal mines?*
A. Leaving doors open.
451. Q. *What is the principal cause of ignition of explosive mixtures?*
A. Electric arcs.
452. Q. *What is the second most common cause of ignition of explosive mixtures?*
A. Open lights.
453. Q. *How can mine explosions be prevented?*
A. By adequate ventilation and the use of closed lights, permissible explosives, and rock dust, and the safeguarded use of electricity.
454. Q. *What can be done to prevent a possible explosion from being propagated by coal dust?*
A. The mine can be rock-dusted.
455. Q. *What is the first thing to be done on the surface of a mine after an explosion?*
A. See that the ventilating fan is operating properly.
456. Q. *What is the most important duty of the electrician after a mine explosion?*
A. He should pull and lock out all electrical switches leading into the mine.
457. Q. *With ventilating apparatus working properly, what precaution should be taken to protect the lives of possible survivors?*
A. An endeavor should be made to ascertain their names and probable location.
458. Q. *What should be the duty of police guards after a mine explosion?*
A. They should rope off an area around the entrance and admit authorized persons only.

459. Q. *What should be the duty of the mining engineer after a mine explosion?*
A. He should furnish an up-to-date map of the mine, showing the regular coursing of the air, and keep it posted to show the progress of recovery.
460. Q. *What agencies should be notified immediately when a mine explosion occurs?*
A. The State Mine Inspection Department and the Federal Bureau of Mines.
461. Q. *How should recovery work be divided after a mine explosion where such work may be extensive?*
A. In four 6-hour shifts or three 8-hour shifts a day.
462. Q. *Who are eligible to supervise crews on each shift in recovery work after a mine explosion?*
A. Men with experience and special training in recovery operations.
463. Q. *What is the minimum number of apparatus crews that should be employed underground at a time in recovery work after a mine explosion?*
A. At least two.
464. Q. *What precautions should be taken before men are permitted to enter a mine after an explosion, assuming that fans are operating properly?*
A. All men should be properly checked and searched and only authorized persons should carry permissible flame safety lamps.
465. Q. *What types of workers should be on each shift in recovery work following a mine explosion?*
A. All-service gas-mask crews, trained oxygen-breathing-apparatus crews, and fresh-air labor crews to build stoppings and carry material and stretchers. (*See* fig. 42.)
466. Q. *What should be the qualifications of men on oxygen-breathing-apparatus crews?*
A. They should be well-trained, physically fit, and competent.

FIGURE 42.—A mine rescue crew prepares to enter a mine after an explosion.

467. Q. *What equipment should rescue parties wear?*
A. Respiratory apparatus crews should wear self-contained oxygen breathing apparatus or all-service gas masks, and all men engaged in recovery work should carry self-rescuers and electric cap lamps.
468. Q. *What means of gas detection should be provided rescue parties?*
A. Permissible flame safety lamps and carbon monoxide detectors or canaries if no carbon monoxide detectors are available.
469. Q. *What material should be provided for recovery work?*
A. Brattice cloth, boards, brick, tile, cement, copper hammers, and other hand tools.
470. Q. *What first-aid equipment should be provided for recovery work?*
A. Oxygen inhalators, first-aid supplies, and stretchers.
471. Q. *What fire-fighting equipment should be provided for recovery work?*
A. Fire extinguishers of proper type and rock dust.
472. Q. *In recovery work, at what point underground is it advisable to have a first-aid station?*
A. Near the fresh-air base.
473. Q. *After a mine is entered following an explosion, what examination should be made at once?*
A. Return airways should be examined for smoke or indications of fire.
474. Q. *What particular danger is present if ventilation is restored after an explosion, before an exploration is made?*
A. Dormant fires may be revived, and an explosion may follow.
475. Q. *What chief factors determine the location and establishment of a fresh-air base in mine recovery work?*
A. The fresh-air base must be in fresh air, free from possible contamination by poisonous and explosive

gases, secure against roof falls, and readily accessible for rescue and recovery operations.

476. Q. *What breathing apparatus may be used for exploration beyond fresh air?*

A. Self-contained oxygen breathing apparatus or all-service gas masks. (*See* fig. 43.)

477. Q. *What atmospheric conditions will not permit the use of an all-service gas mask?*

A. Where a safety lamp will not burn or cannot be used safely, or where the carbon monoxide content exceeds 2 percent.

478. Q. *Where is it essential that self-contained oxygen breathing apparatus be used?*

A. Where a flame safety lamp will not burn or cannot be used safely, or where the carbon monoxide content exceeds 2 percent.

479. Q. *Is it advisable to explore ahead of fresh air in dense smoke?*

A. Only to save lives or in an emergency.

480. Q. *Under what conditions of travel is it inadvisable to explore ahead of fresh air?*

A. When necessary to crawl or to wade in deep water.

481. Q. *In the course of recovery work, if men are discovered alive but not physically fit to travel on their own strength, how should they be treated?*

A. They should be transported to the fresh-air base and given first-aid treatment. They should then be permitted to recuperate to some extent before being sent outside.

482. Q. *Why should men be kept at the fresh-air base after rescue until partly recuperated?*

A. Because of the severe physical reaction caused by the outside atmosphere.

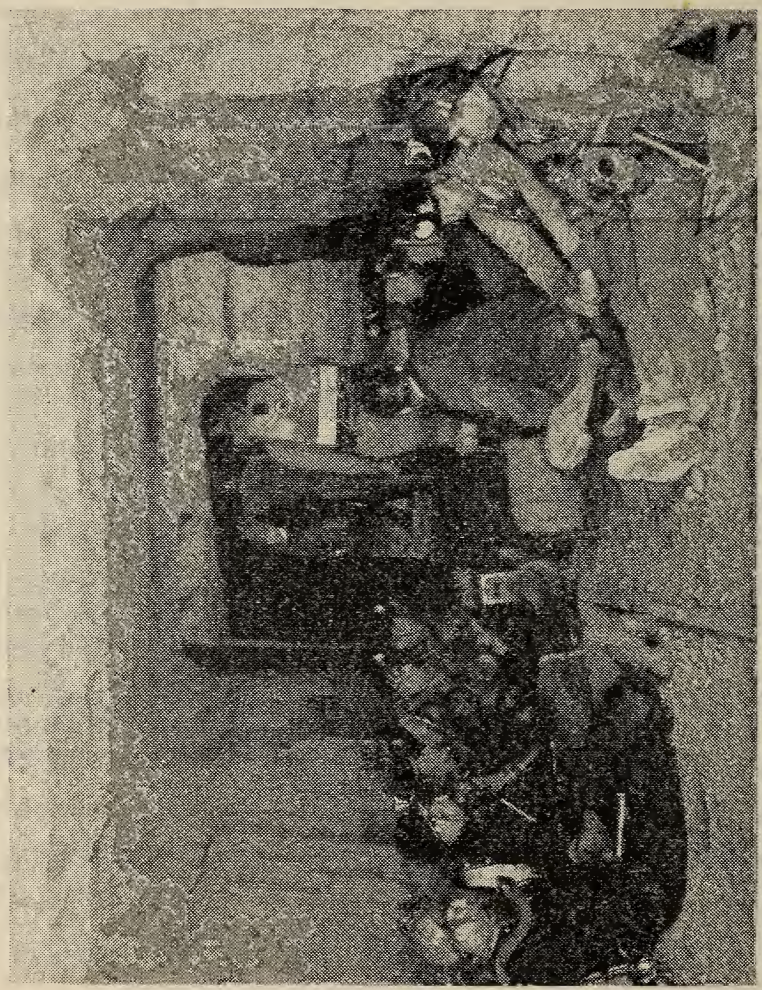

FIGURE 43.—Oxygen-breathing-apparatus crew leaving fresh-air base for an exploration trip after mine explosion.

483. Q. *When reestablishing ventilation for recovery operations after an explosion, what type of stoppings should be used?*
A. Wood and brattice cloth or boards and plaster.
484. Q. *What should be done when fires are found during recovery explorations?*
A. Every effort should be made to extinguish them. If fire is inaccessible it should be sealed at once.
485. Q. *Why is it advisable to have telephones at the fresh-air base?*
A. To expedite the transmission of messages and instructions.
486. Q. *Why should maps of the mine be available for the men in charge of recovery?*
A. So that rescue and recovery work can be planned and executed systematically.
487. Q. *Where should the shifts be changed when recovery work is in progress?*
A. At the fresh-air base.
488. Q. *What precautions should be taken when men are coming off shift from recovery operations?*
A. Men should be checked out of the mine.
489. Q. *What precautions should be observed by men as they advance in the process of restoring ventilation?*
A. Dangerous gases should not be permitted to issue from adjoining open dead ends or unventilated areas.
490. Q. *When ventilation is being restored, what precautions should be taken at open dead ends and other open areas encountered?*
A. They should be cleared of dangerous gases or sealed temporarily.
491. Q. *What is the most harmful gas in afterdamp?*
A. Carbon monoxide.

492. Q. *What is a barricade?*
A. A stopping erected to prevent gases from an explosion reaching an unaffected part of the mine where men may remain safely until rescued.
493. Q. *Have barricades been successful in preserving life after mine fires and explosions?*
A. Yes; in many instances.
494. Q. *How many instances are on record in which barricades have saved the lives of miners?*
A. According to the records of the Bureau of Mines, barricades have saved the lives of miners on 38 occasions.
495. Q. *According to the records, how many lives have been saved by the use of barricades?*
A. 876 lives have been saved by the use of barricades.
496. Q. *How may barricades be constructed?*
A. From any suitable material at hand, such as gob, stopping material, ties taken from track, brattice cloth, or new or used lumber.
497. Q. *Should an explosion occur, and the entries leading to the surface from a section in which men are working be filled with the gases of the explosion, what is the safest thing to do?*
A. Short-circuit the ventilation from the section, and erect a barricade.
498. Q. *What can be done to prevent the gases of an explosion from reaching the point where a barricade is to be erected?*
A. By short-circuiting the air at least 50 feet outby the place and erecting a temporary curtain.
499. Q. *How large an area should be enclosed within a barricade?*
A. As large as possible.
500. Q. *While within a barricade how should a person conduct himself?*
A. He should remain quiet, but move about occasionally to mix the air.

501. Q. *What should be done with flame lamps within a barricade?*
A. They should be extinguished. They deplete oxygen and may cause an explosion.
502. Q. *How can compressed air, if available, be of assistance within a barricade?*
A. It can be used to replenish the air.
503. Q. *How much air does the average person require per hour within a barricaded area when at rest?*
A. About 1 cubic yard per hour.
504. Q. *When gases begin to enter a barricade, what can be done?*
A. If the place is large enough, additional barricades can be built inby the first ones erected, or the crevices can be plugged with brattice cloth or clothing.

PREVENTION OF ACCIDENTS BY EXPLOSIVES

TYPICAL EXAMPLES OF EXPLOSIVES ACCIDENTS

1. A place was being driven off a haulageway, and a shot hole had been drilled about 11 inches from the back of the cut. This hole was charged with a Cardox shell, which lacked 26 inches of being to the back of the hole. A machine helper was standing on the haulageway about 59 feet from the switch leading into the place where the shot was fired. He was struck by the shell, which flew out of the face, struck a header post at the switch 40 feet from the face, and glanced down the haulageway. The machine helper was killed.

Cardox should not be fired unless it is confined properly in the borehole with stemming.

2. A loader was engaged in loading a hole with permissible explosives. Two sticks of explosives were placed in the hole, the electric detonator was inserted in the third stick, and the shunt was removed from the leg wires. As the loader was placing this primer in the borehole, the leg wires came in contact

with a steel car at the face, and a stray current discharged the stick of explosives in his hand.

Detonator leg wires should be kept shunted until ready to be connected to the firing cable. Even with this precaution, extreme care should be exercised to see that the ends of detonator leg wires never come in contact with metallic objects that may be subject to stray currents.

3. A miner and his buddy were greasing a loading machine near the face of a heading. A break-through from the adjoining heading was nearly holed through. An inexperienced man was shooting the break-through and did not give direct warning to the miner and his buddy. When the shot was fired, it broke through, and the miner was struck by flying coal. He died 3 hours later.

When places are about to be "holed through," a warning should be given to persons working in the adjacent place. Blasting coal is a dangerous operation and should be entrusted to properly trained and skilled workmen only.

4. A hole charged with permissible explosive had failed to go off at a conveyor face. Another hole was drilled about 16 inches from the misfired hole and fired. No examination was made to see whether the original charge was fired. After the place had been cleaned up and cut again, the miner apparently was starting to drill a hole for the new cut when the misfire went off and killed him instantly.

Misfires should be removed under the direct supervision of a foreman who should make every effort to determine whether or not the misfired charge was exploded and to recover any explosive that may not have been detonated.

5. A shot was ready for firing in a pillar place that was nearly cut through to an adjoining entry. While a miner was connecting the shot, his buddy walked into the entry to warn others of the shot. He apparently misjudged the distance and called that all was clear, but he was stationed where the shot broke through. He was struck by flying coal and died the next day as a result of his injuries.

Errors in judgment sometimes are a form of carelessness. This man should have made sure of his location before giving the signal to fire.

5. One miner will spend the remainder of his life in blindness because of an accident from a delayed blast. He lighted a black-powder shot, and when it did not explode as soon as expected he returned to the face. The explosion burned his face and eyes so badly that physicians say the sight of both eyes is lost permanently.

No attempt should be made to go back to a misfire before 24 hours has elapsed, when squibs, fuse, or delay electric detonators are used.

6. A miner was attempting to recover a misfired charge of permissible explosives by removing the stemming material with a coal auger; the auger cut into the blasting cap, which detonated the charge. The miner was injured so badly by flying coal that he died.

Misfired charges should be recovered only under the direct supervision of a mine official by drilling a hole parallel to the misfired hole at least 1 foot away and blasting the new hole or by washing the stemming material out of the hole with water.

QUESTIONS AND ANSWERS

USE AND HANDLING OF EXPLOSIVES

1. Q. *How many underground coal miners were killed by explosives (mine explosions excluded) in 2 recent typical years?*
   A. 32 in 1939 and 35 in 1940.
2. Q. *What percentage of the total number of underground coal miners killed in 1939 and in 1940 was killed by explosives?*
   A. 3 percent in 1939 and almost 3 percent in 1940.

3. Q. *Why is black blasting powder dangerous for use in any mine?*
   A. Because of its sensitiveness to ignition and its ability to ignite gas and coal dust.
4. Q. *What dangers accompany the use of black blasting powder in coal mines?*
   A. Fires, premature explosions, gas and dust explosions, and poisonous gases.
5. Q. *Is black powder in pellet form safer to use than in granular form?*
   A. No; either form is equally dangerous.
6. Q. *What is the principal ingredient in a permissible explosive generally used for shooting coal?*
   A. Ammonium nitrate.
7. Q. *How should a permissible explosive be fired?*
   A. By an electric detonator fired by a permissible blasting unit.
8. Q. *What are the dangers from burning explosives?*
   A. Fires, explosions, and dangerous gases.
9. Q. *What quantity of explosives is an employee permitted to take into a mine?*
   A. No greater quantity than he may reasonably expect to use in any one shift.
10. Q. *How should employees be prevented from taking an excessive amount of explosive into a mine?*
    A. By having the use of explosives strictly regulated and checked.
11. Q. *How should explosives be carried into a mine?*
    A. They should be enclosed in nonconducting boxes and carried separately from firing devices. (*See* figs. 44 and 45.)
12. Q. *How may explosives be hauled by electrically operated trips?*
    A. In enclosed, nonconducting boxes, on special trips.

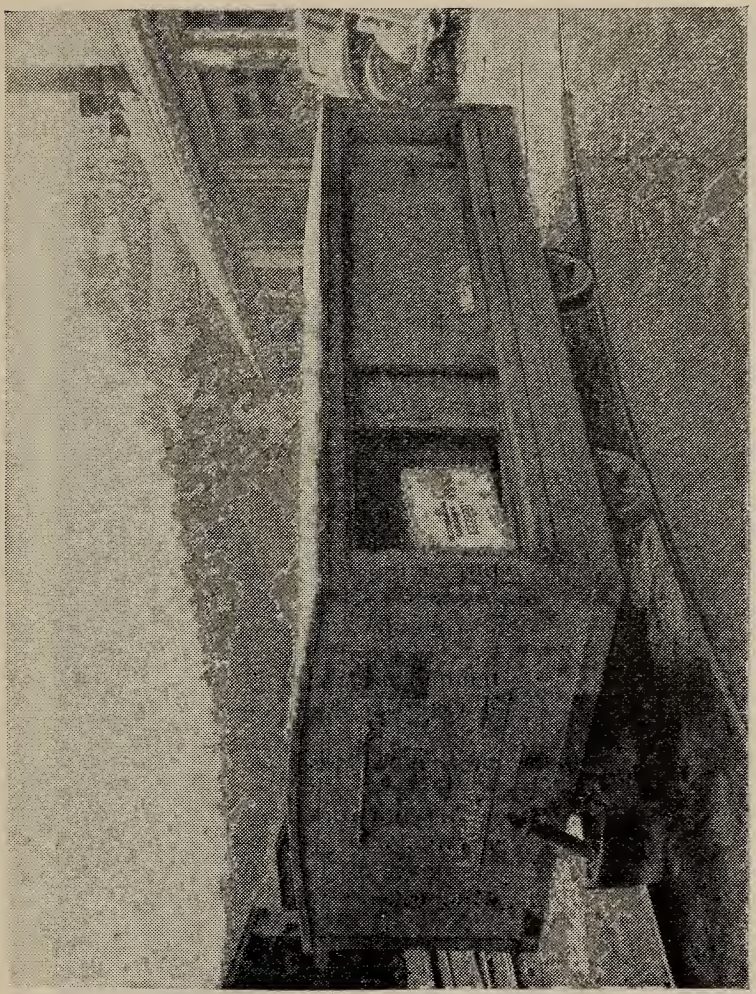

FIGURE 44.—Explosives should be transported into the mine in well-constructed, insulation-lined explosives cars.

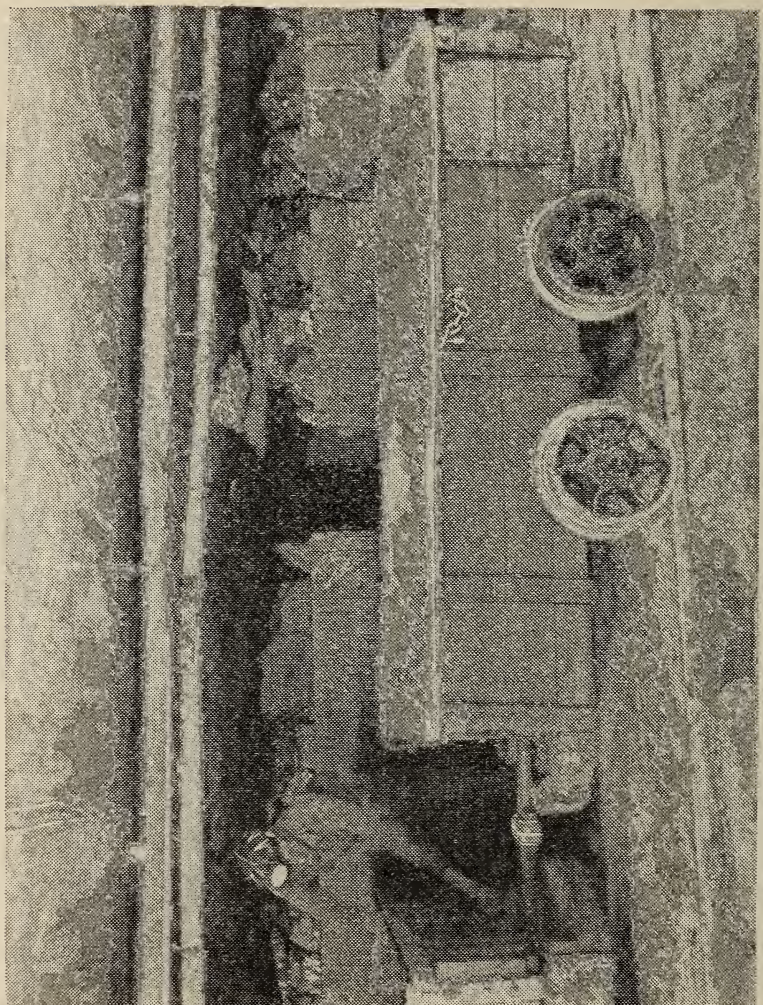

FIGURE 45.—An insulated coupling should be used when explosives cars are hauled by electric locomotives.

13. Q. *What should be the provisions relative to carrying explosives on trips that carry workmen?*
    A. Explosives should not be carried on trips that carry workmen.
14. Q. *What interval should be maintained between a trip carrying explosives and a man trip?*
    A. Not less than 5 minutes.
15. Q. *In what direction should the air travel relative to a man trip and one carrying explosives?*
    A. From the man trip toward the explosives trip.
16. Q. *How should explosives and firing devices be kept with respect to each other?*
    A. They should be kept separate.
17. Q. *How should explosives be stored at the face?*
    A. In a dry place free from the danger of stray electric currents or flying objects.
18. Q. *How should explosives and blasting caps be kept in a mine?*
    A. In insulated locked containers.
19. Q. *Where should explosives and blasting caps not be hidden?*
    A. They should not be buried in the gob.
20. Q. *Within what point from the face should explosives and blasting caps not be kept?*
    A. Inby the firing station.
21. Q. *How should unused explosives and detonators be disposed of at the end of a shift?*
    A. They should be returned to the distributing magazine.
22. Q. *What are the practical benefits of proper stemming?*
    A. The shot is more effective and less likely to ignite gas or dust.
23. Q. *What kind of a stemming tool should be used?*
    A. A wood tamping stick. (*See* fig. 46.)

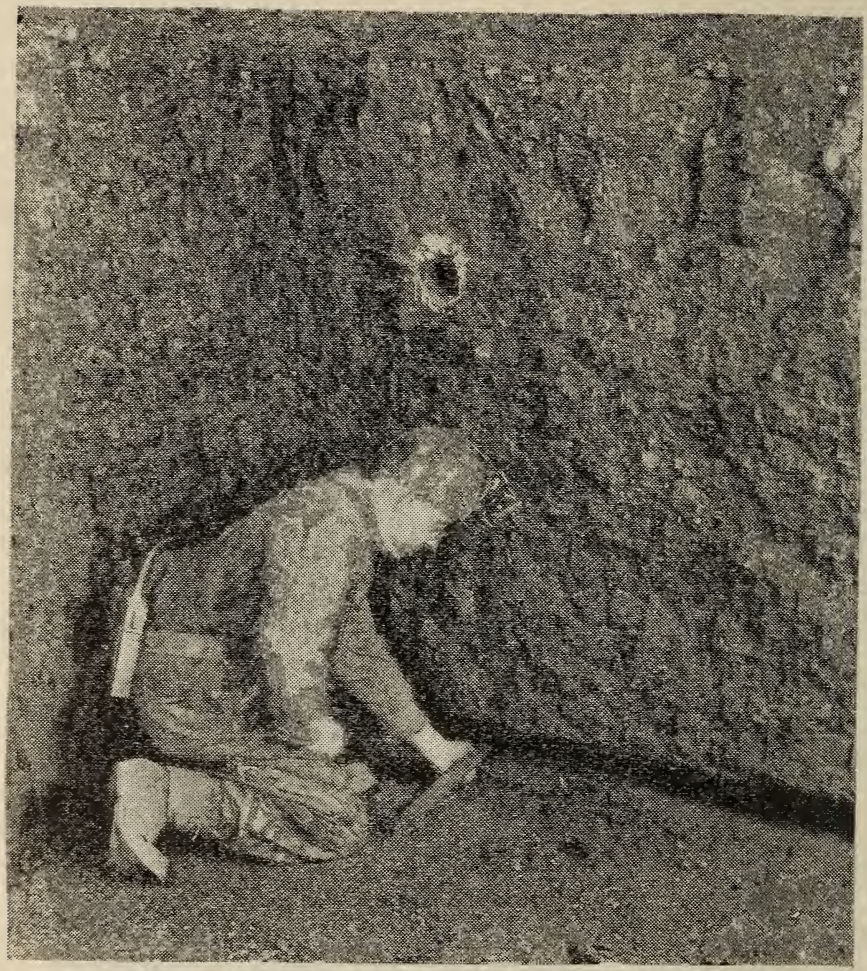

FIGURE 46.—The tamping stick is used to measure the depth of the undercut and to gage the depth and location of the borehole.

24. Q. *What should be the maximum length of a metal scraper attached to wood tamping bars?*
    A. 8 inches.
25. Q. *What kind of stemming tools should be prohibited?*
    A. Metal or metal-clad tamping bars.
26. Q. *What may be the danger of an undercharged hole?*
    A. The charge may not be sufficient to break the coal and may result in a blown-out shot. (*See* figs. 47 and 48.)
27. Q. *How soon after charging should holes be fired?*
    A. Promptly. (*See* fig. 49.)
28. Q. *What may be the cause of a premature shot?*
    A. Stray currents, improperly made primers, or tamping the charge too vigorously.
29. Q. *What creates the force when an explosive is fired?*
    A. Sudden expansion of the gases liberated.
30. Q. *What should be the condition of the atmosphere before shots are fired?*
    A. Smoke or dust should not be in suspension, and explosive gas should not be present.
31. Q. *In what direction is the maximum force of the explosive exerted?*
    A. Equally in all directions.
32. Q. *Who should be warned before shots are fired?*
    A. Others in the place and in places about to be cut into.
33. Q. *How should warnings be given when shots are about to be fired?*
    A. By shouting "*Fire*" three times slowly after those notified have withdrawn.
34. Q. *What should persons do when warned that shots are to be fired?*
    A. Withdraw immediately.
35. Q. *Where should persons be when shots are fired?*
    A. Out of the line of fire around a corner as far as the cable or conditions permit. (*See* fig. 50.)

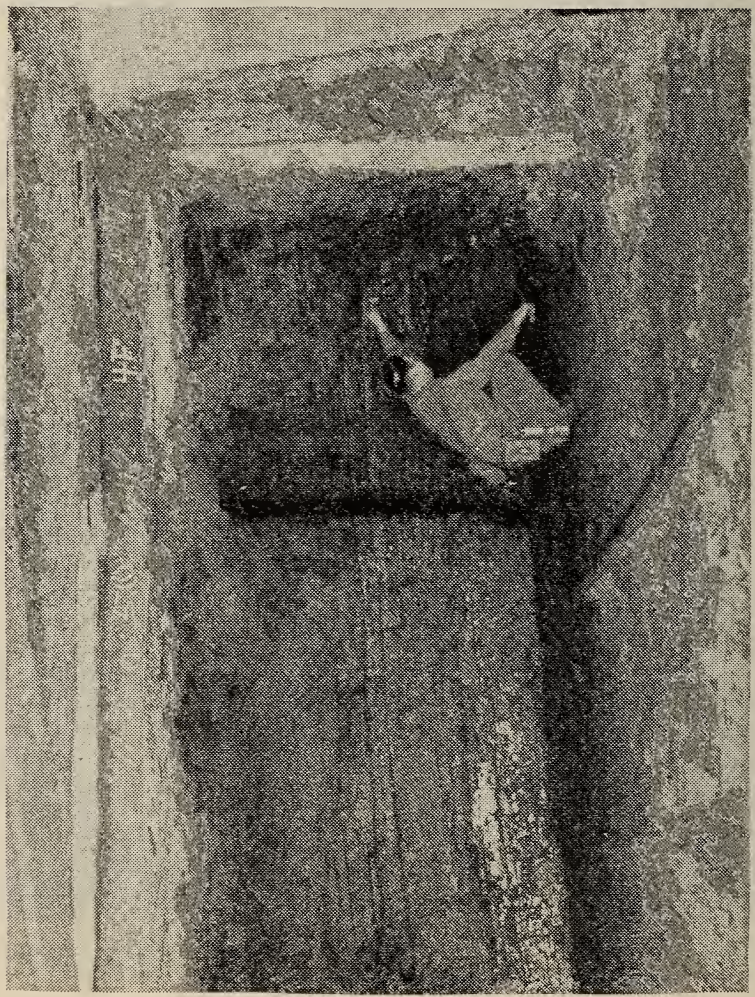

FIGURE 47.—A shot firer should make sure that the coal is properly mined and that the holes are properly placed and not on the solid before charging them.

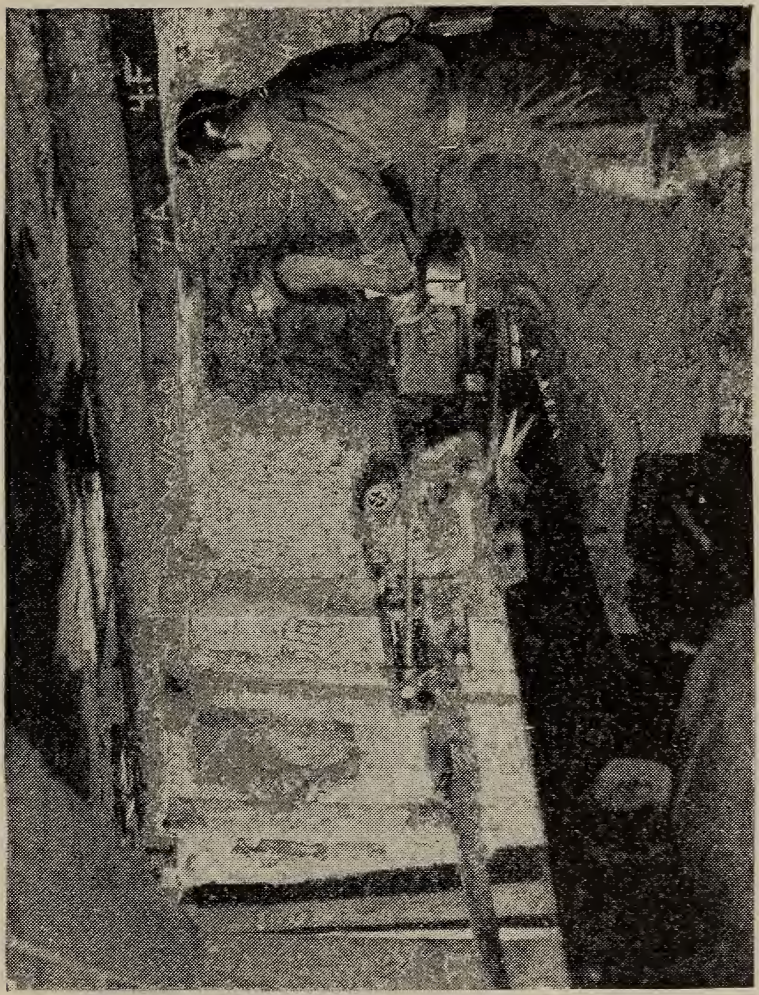

FIGURE 48.—Boreholes for blasting should not be drilled into the solid rib or drilled deeper than the undercut.

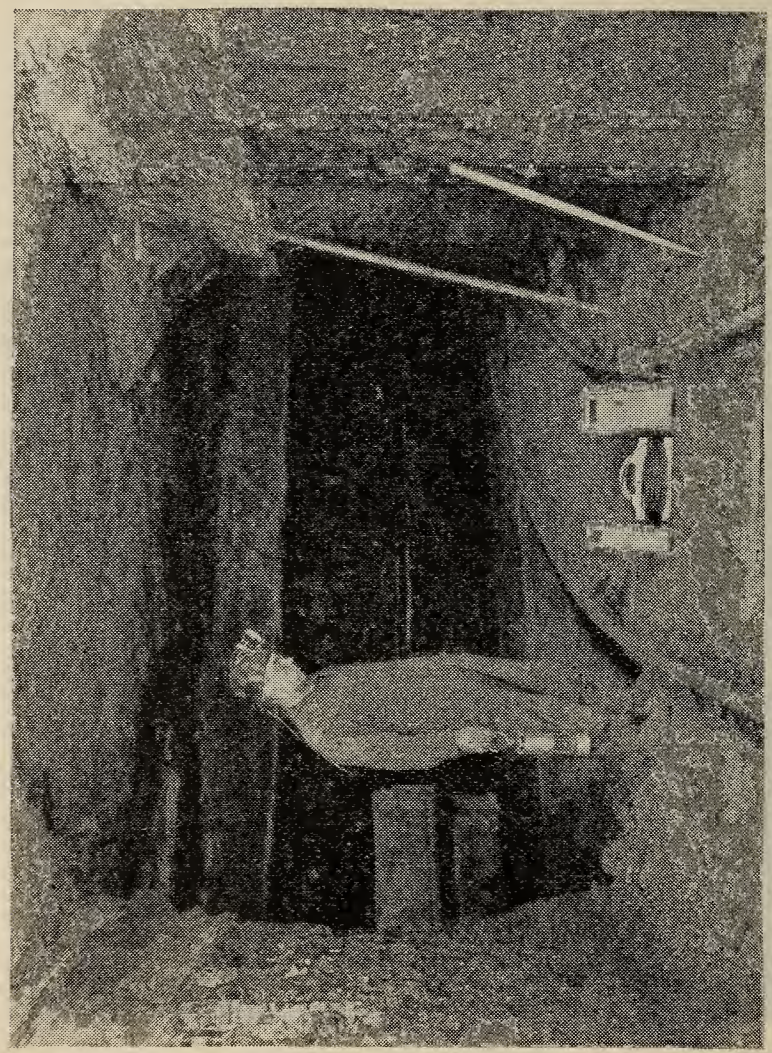

FIGURE 49.—Complete shot-firing equipment consists of a permissible flame safety lamp, a detonator box, a blasting cable not less than 125 feet long, an explosives box, a permissible blasting unit, a wood tamping stick, and a roof-testing stick.

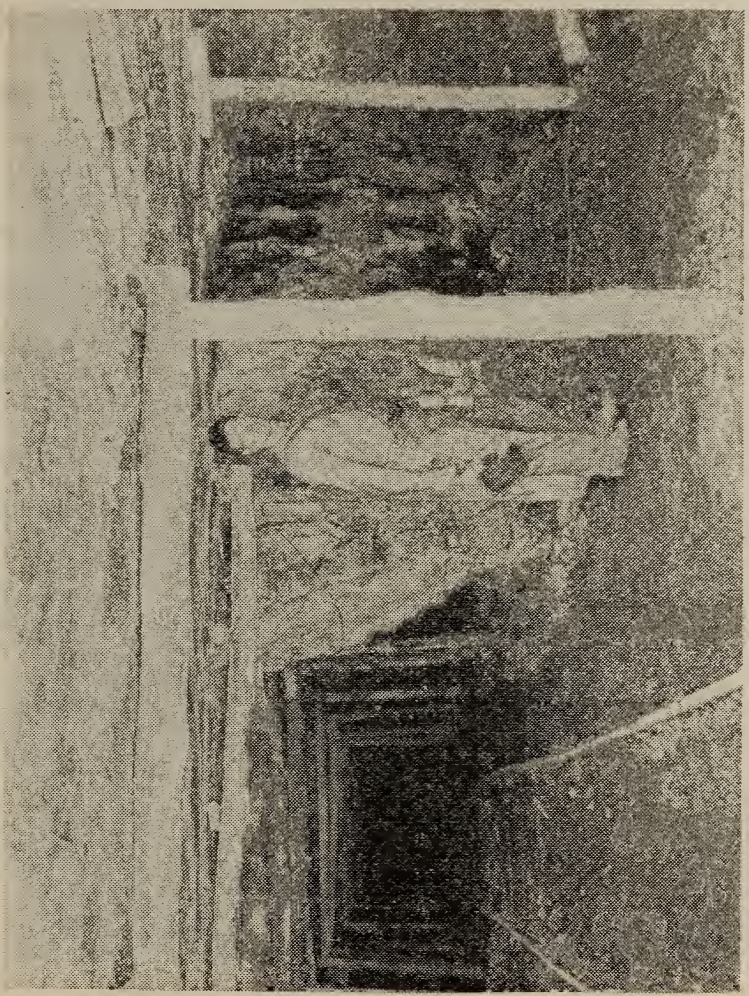

FIGURE 50.—Shot firer gets in the clear, well around a corner, before firing charge.

36. Q. *When should the shot firer make the connection to the shooting cable?*
    A. When other persons are out of the line of fire.
37. Q. *How soon may a person approach the face after a shot has been fired?*
    A. Not until the smoke has cleared away.
38. Q. *What should be done after shooting before work is* resumed?
    A. The roof should be examined and tested for gas and the place made safe.
39. Q. *What is the first thing to do after a misfire when the shot has been fired electrically?*
    A. Disconnect from the blasting unit, short-circuit the blasting cable wires by twisting them together, and wait 15 minutes before returning to the face. (*See* fig. 51.)
40. Q. *When a misfire occurs, how should the place be guarded against injury to others?*
    A. The miner should remain on guard at a safe distance until a foreman arrives.
41. Q. *How should a misfired charge be removed?*
    A. Another hole should be drilled about 1 foot away and fired, or the charge may be recovered by washing the stemming out of the hole with water.
42. Q. *What is the purpose of a new hole after a misfire?*
    A. To blast away the material and expose the charge of the misfired hole so that the explosives can be removed safely.
43. Q. *Who should supervise the removal of a misfire?*
    A. A foreman or regular shot firer.
44. Q. *What method of removing misfires should not be permitted?*
    A. Drilling them out.
45. Q. *How can misfires be prevented?*
    A. By careful selection of the explosives and firing device and correct loading and firing of the charge.

FIGURE 51.—Ends of blasting cable are kept short-circuited until time to connect them to the blasting circuit.

46. Q. *What precaution should be taken to guard against misfires when multiple shooting is done?*
A. A careful examination should be made for misfires after each place has been blasted.
47. Q. *How should explosives be stored?*
A. In cool, dry, well-ventilated magazines.
48. Q. *When powder magazines contain more than an estimated daily supply, what distance should they be located away from mine openings or buildings used by persons?*
A. Not less than 300 feet.
49. Q. *Of what material should the outside of powder magazines be constructed?*
A. Of incombustible material. (*See* fig. 52.)
50. Q. *Where should distributing magazines be established?*
A. Away from stores or other public places.
51. Q. *What accumulations should not be permitted in or around magazines?*
A. Rubbish or combustible material.
52. Q. *What should be posted near magazines?*
A. Warning signs.
53. Q. *What type of tools should be used to open cases of explosives?*
A. Wood tools. (*See* fig. 53.)
54. Q. *What are the principal dangers from the use of fuse or miners' squibs?*
A. Premature explosions, misfires, and hangfires.
55. Q. *How is a premature explosion caused by the use of a fuse?*
A. By too short or defective or damaged fuse.
56. Q. *What is ordinarily used to fire dynamite?*
A. Electric detonators or fuse blasting caps.
57. Q. *Should fuse and squibs be used in coal mines?*
A. No.

FIGURE 52.—Main explosives magazines should be constructed of lean cement mortar, located in isolated places, and shielded by earth barricades.

FIGURE 53.—A wood mallet and wedge should be used for opening cases of explosives.

58. Q. *How is an electric blasting cap protected from stray currents?*
A. By shunting the ends of the leg wires.
59. Q. *What is a shunt, such as is used on an electric squib or electric blasting cap?*
A. It is made by short-circuiting the end of the leg wires. (*See* fig. 54.)
60. Q. *When should a shunt on leg wire be removed?*
A. Not until ready to connect to the shot-firing cable.
61. Q. *What is the proper type of shot-firing cable?*
A. A rubber-covered, two-conductor, flexible cable at least 125 feet long.
62. Q. *What precautions should be observed when unwinding shot-firing cable?*
A. Care should be taken to keep it from touching rail, wire, pipe, or bottom, which may carry stray electric currents. The safest practice is to hang the cable on timbers. (*See* fig. 55.)
63. Q. *Who should connect and handle the shooting cable?*
A. The person who fires the shot.
64. Q. *How should the shot-firing cable be handled between the charge and the "firing station"?*
A. It should be unreeled from the charge toward the "firing station."
65. Q. *What should be the minimum length of a shot-firing cable?*
A. 100 feet. As originally provided, it should be 125 feet long.
66. Q. *What should be a requirement of shooting cables relative to strength?*
A. They should be mechanically strong to prevent excessive stretching.
67. Q. *How should shooting cables be maintained?*
A. Free from cuts and abrasions.

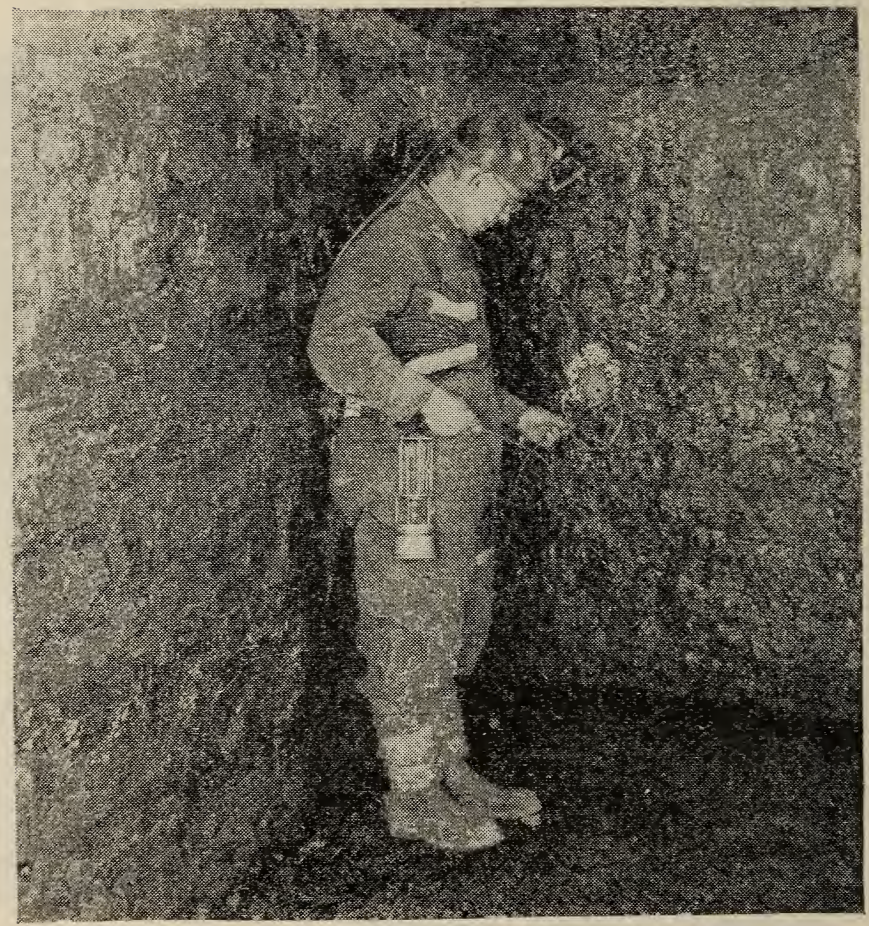

FIGURE 54.—The ends of detonator leg wires and blasting cable are staggered to avoid the likelihood of short circuits and resulting misfires.

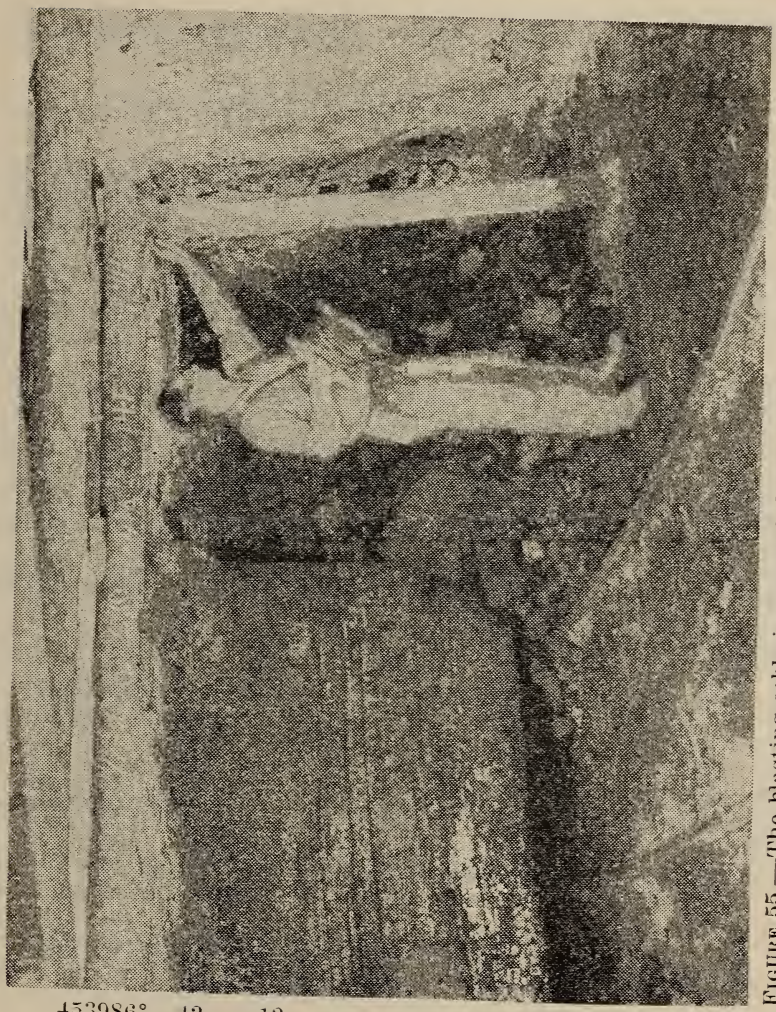

FIGURE 55.—The blasting cable is suspended on timbers to avoid picking up a stray current that would cause a premature explosion.

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68. Q. *How may shooting cables be protected from stray currents?*
A. By being shunted and kept off the floor.
69. Q. *How can shot-firing cables be tested to see that they are not charged?*
A. First, by touching the wires together and, if no sparks appear, by touching the two wires to the tongue. A stray current would be indicated by a slightly "salty" taste.
70. Q. *What is the greatest danger from electric firing?*
A. Current may be applied before the men have reached a safe place or stray currents may cause a premature explosion.
71. Q. *When should blasting caps be placed in explosives?*
A. Not until the holes are ready to be charged.
72. Q. *What type of electric blasting caps should not be used in coal mines?*
A. Delay blasting caps.
73. Q. *Where should the blasting cap be placed when a borehole is charged?*
A. It should be placed centrally in the primer and pointed toward the body of the charge.
74. Q. *What is the primer used to fire a charged hole?*
A. A cartridge with the blasting cap inserted.
75. Q. *How should the blasting cap be inserted in a primer?*
A. By inserting it full length into one end so that the loaded end is on the axial line.

NOTE.—Additional information on blasting appears in the section, Prevention of Gas and Dust Explosions and Mine Fires, under Explosives, p. 126

76. Q. *How many holes may be loaded or fired at one time?*
A. No more than one hole should be loaded and fired at a time?
77. Q. *How soon should shots be fired after they are charged?*
A. Shots should be fired promptly after they are charged.

78. Q. *What record should be kept in connection with blasting?*
A. 1. The amount of explosives and detonators taken into and returned from the mine.
2. The number of misfired shots.
3. The number of blown-out shots.
4. Any holes the shot firer refuses to charge or fire.

79. Q. *How should Cardox shells be transported underground?*
A. Cardox shells should be transported underground in insulated boxes placed in ordinary mine cars.

80. Q. *How can premature blasts of Cardox be prevented?*
A. By keeping the bare ends of the shell wires short-circuited until ready to be connected to the blasting cable.

81. Q. *How do safety precautions as regards the firing of Cardox compare with those when permissible explosives are fired?*
A. The same safety precautions must be taken.

82. Q. *Is it necessary to stem holes charged with Cardox?*
A. Yes; all Cardox shots should be stemmed to the collar of the hole.

83. Q. *Where should Cardox charging stations be situated?*
A. They should be outside of the mine in a fireproof structure, a safe distance from other structures.

84. Q. *Where should the Cardox storage tank be placed?*
A. Outside the building.

85. Q. *What safeguards should be provided on a Cardox storage tank?*
A. The tank should be provided with at least two methods of relieving excess pressure.

86. Q. *Where should the Cardox heating elements be stored?*
A. They should be stored in a separate magazine that complies with the requirements for storage of other explosives.

87. Q. *What special precautions should be taken when Cardox shots are fired?*
A. Everyone in the vicinity should be in a safe place, preferably around two corners.

PREVENTION OF ELECTRICAL ACCIDENTS

TYPICAL EXAMPLES OF ELECTRICAL ACCIDENTS

1. A trailing cable on a cable-reel locomotive had been spliced with a splicing clamp. One of the points had not been driven into position properly; the sharp end of the clamp had worked through the tape and was in contact with the top plate of the cable reel. While a timberman was waiting for a drilling crew to finish its work he sat on the corner of the locomotive and was electrocuted when he came in contact with the reel.

The trailing cable should have been spliced properly, and the insulation should have been vulcanized at the splice.

2. A workman was dragging a section of conveyor from a completed room with the cutting machine. He did not notice that the trailing cable had been fouled by a fall of slate and the ground wire had been pulled apart. As the machine was pulled toward the jack, the cable became so stretched across the edge of the machine as to break the insulation. The workman was electrocuted when the frame of the machine became charged by the 440-volt current.

Currents exceeding 250 volts should not be used for operating portable electrical equipment in mines; moreover, the workman should have kept closer watch over his trailing cable.

3. An empty car had been derailed on a sidetrack. A laborer was using a piece of timber as a lever to rerail the car, and as he raised up to adjust a block under the lever he came in contact with the trolley wire and was electrocuted.

Where men are required to work or pass under bare power wires less than 6½ feet above the rail, suitable protection should be provided. In the absence of such protection, the man should have declined to work under the unprotected trolley wire.

4. A miner was on his way to an adjoining room and passed under an unguarded trolley wire to let the gathering locomotive go by. When he stepped back to the track he came in contact with the wire and was electrocuted.

This miner should not have passed under an unguarded trolley wire if it was less than 6½ feet above the top of the rail.

5. A fireboss had taken a gathering locomotive to reach a section where he was to make a fireboss run. He had reached a point under low top where the trolley wire was directly over the rail. Apparently, as he tried to get out of the locomotive he touched the wire and then plunged forward, and his head became wedged between the trolley wire and the roof. He was electrocuted.

If the trolley wire had been installed at least 6 inches outside the rail this accident might not have happened.

QUESTIONS AND ANSWERS

1. Q. *How many underground coal miners were killed by electricity in 2 recent typical years?*
   A. 51 in 1939 and 37 in 1940.
2. Q. *What percentage of the total number of underground coal miners killed in 1939 and 1940 was killed by electricity?*
   A. 5 percent in 1939 and 3 percent in 1940.
3. Q. *What hazards are created by the use of electricity in mines?*
   A. Mine explosions, mine fires, electrocutions, electric shock, electrical burns, and injury to the eyes from electric flashes, as well as premature firing of explosives by stray currents.
4. Q. *How can excessive line loss be avoided?*
   A. By ample current-carrying capacity in the conductors, by adequate bonding, and by locating generating sets near the point of operation. (*See* figs. 56, 57, and 58.)
5. Q. *What are some effects upon operating motors of overload and undervoltage?*
   A. Inefficient operation, abnormal heating, possible burnouts, and decreased speed.

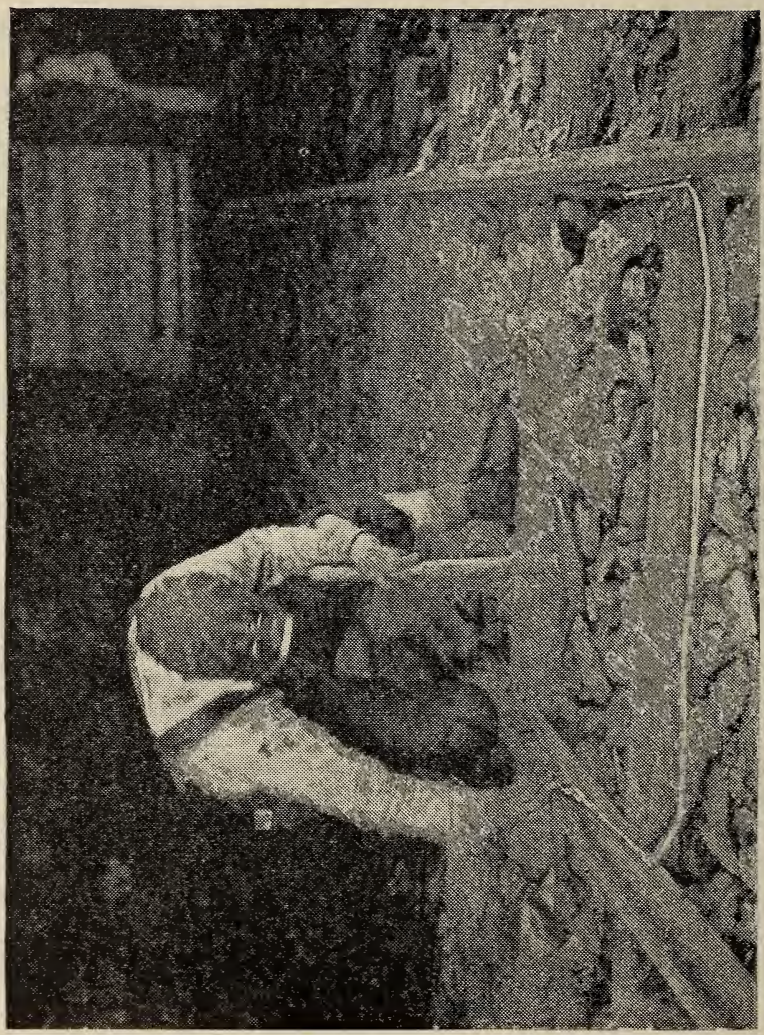

FIGURE 56.—Rails should be bonded at every joint, and crossbonds should be installed on haulage roads at intervals of not more than 200 feet.

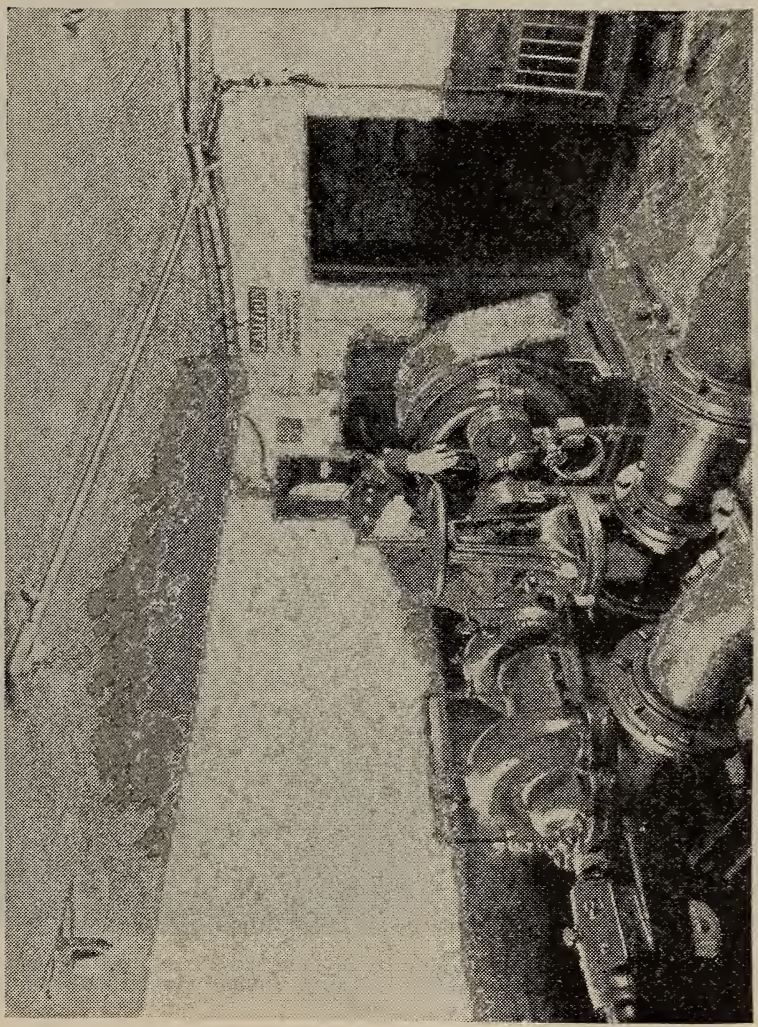

FIGURE 57.—Underground pumping stations should be of fireproof construction and well-illuminated, with all moving parts of machinery effectively safeguarded.

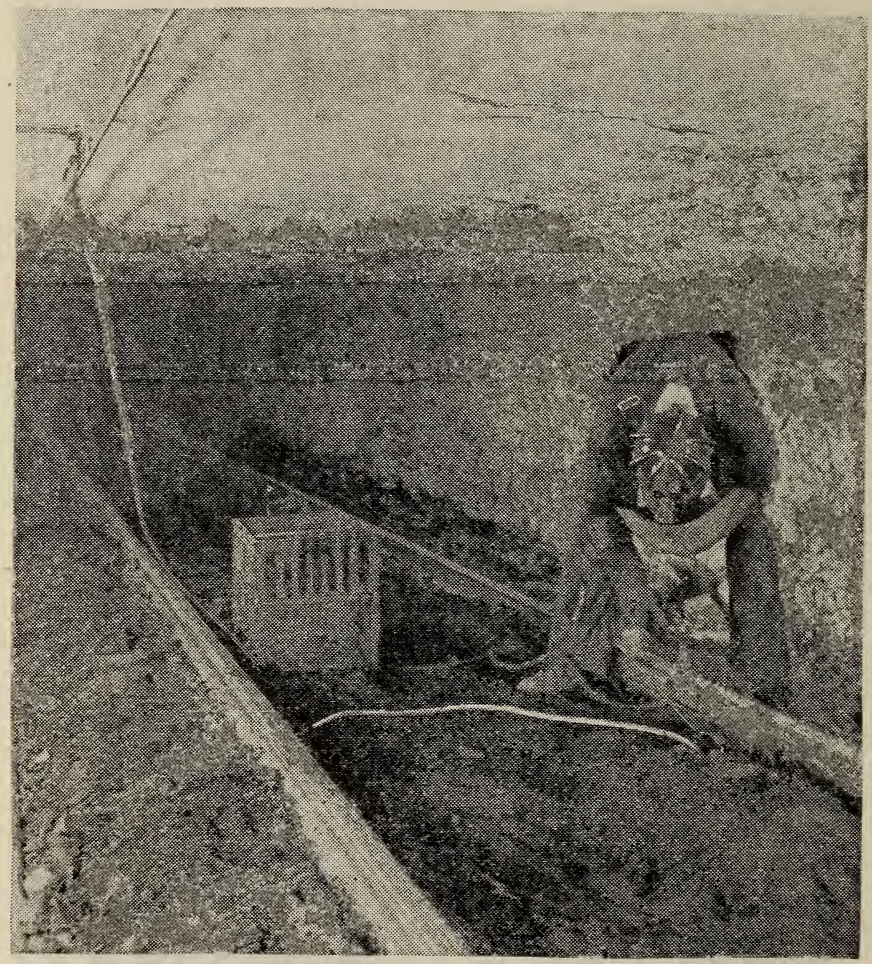

FIGURE 58.—Where bonding is done by electric arc, eyes and face must be protected by a welder's shield. Heavy rubber gloves will protect hands and guard against electric shock.

6. Q. *What protective devices should be installed on all power lines entering the mines?*
   A. Properly grounded lightning arresters and circuit breakers.
7. Q. *From a safety standpoint, what should be the maximum voltage used in mines at working faces?*
   A. 250 volts.
8. Q. *At what places in the mine should trolley and feeder wires be guarded?*
   A. At all branch roads, side tracks, cross-overs, room necks, doors, sand boxes, supply stations, man-trip loading zones, and other places where the wires are less than 6½ feet above the rail. (*See* figs. 59 and 60.)
9. Q. *What safeguard should be provided where bare power wires are less than 6½ feet above the rail?*
   A. Suitable protection, such as guard boards or channeling of the roof, so that the lowest point of the wire is at least 2 inches above the lowest part of the guard.
10. Q. *Where should protection from power wires be provided at doors?*
    A. On both sides of doors where men are exposed to the wire.
11. Q. *What protection should be provided for men who are temporarily assigned to work under an unguarded trolley or feeder wire?*
    A. The trolley or feeder wire should be provided with temporary guardboards.
12. Q. *Where should the trolley wire be installed with respect to the rail?*
    A. At least 6 inches outside the rail and on one side only.
13. Q. *For what purpose is the trolley wire installed outside the rail?*
    A. To reduce danger of contact with the locomotive operator, mobile equipment, and persons traveling on a haulageway.

FIGURE 59.—Where permissible junction boxes are not used, cables that supply power to portable machines should be attached to the trolley wire by a fused clamp.

FIGURE 60.—Trailing cables of portable machines should be suspended on hooks to keep them from being run over and damaged by moving machinery.

14. Q. *How should machine or feed wires be installed?*
    A. On insulators, free from contact with the coal, rib, or roof and away from timber, brattice cloth, or other material that will burn.
15. Q. *Where should machine or feed wires be installed relative to the trolley wire?*
    A. On the same side as the trolley wire.
16. Q. *On which side should trolley or feed wires be installed?*
    A. On the side opposite to the clearance and to refuge holes or necks of rooms.
17. Q. *When may trolley or feed wires be placed across the necks of rooms?*
    A. When full protection is provided by guards.
18. Q. *How should joints in trolley and permanent power wires be made?*
    A. By proper splicing so that the joints are as strong electrically and mechanically as the conductor.
19. Q. *What should not be permitted at the ends of power wires?*
    A. Sharp projecting ends. The ends of power wires should be enclosed properly.
20. Q. *How should conductors and equipment be protected against overloads?*
    A. By proper fusing or by circuit breakers set properly to protect against overload.
21. Q. *How does the proper use of fuses or circuit breakers afford protection?*
    A. By automatically opening the circuit when a short circuit or an overload occurs.
22. Q. *How can the hazards of defective wiring be lessened?*
    A. By regular, systematic inspection at least once a month and by thorough maintenance.
23. Q. *Why should trolley and feeder circuits be kept away from working faces in gassy mines?*
    A. Because of the danger from arcs in a possible accumulation of methane.

24. Q. *Where should trolley frogs be provided?*
A. At all intersections.
25. Q. *Where should sectionalizing switches or circuit breakers be placed?*
A. On each branch circuit and not over 1,000 feet apart on haulageways.
26. Q. *What precaution should be taken before repairs to a trailing cable are attempted?*
A. The power should be cut off by disconnecting the cable from the trolley wire or other source of power.
27. Q. *How should temporary trailing-cable splices be made?*
A. In a workmanlike manner, with the joints electrically and mechanically strong and fully protected with insulation.
28. Q. *What maximum length of time should trailing cables with temporary splices be kept in service?*
A. Not more than 24 hours.
29. Q. *How and where should permanent splices be made in trailing cables?*
A. Permanent splices in trailing cables should be strongly made and vulcanized in the surface or underground machine shop.
30. Q. *What precaution should be taken with the trailing cables when machines are not in use?*
A. Power should be cut off by disconnecting the cable from the trolley wire or other source of power.
31. Q. *How should trailing power cables be maintained?*
A. Free from temporary splices, cuts, or abrasions.
32. Q. *How should all power lines be guarded to afford protection to the equipment which they serve?*
A. They should be properly fused near the power supply.
33. Q. *What precaution should be taken before work is done on power wires?*
A. The power should be cut off and, as a further protection against electric shock, hard-toe rubber shoes and

linesman's rubber gloves (*see* fig. 58) should be worn.

34. Q. *What precaution should be taken to guard against electrical hazards in a section where supervision has ceased?*
    A. The power should be cut off.
35. Q. *How should electric wires be protected from contacts when installed within structures or in the mine?*
    A. By proper insulation.
36. Q. *What type of power wire should be used to serve stationary electrical equipment?*
    A. Insulated wire (rubber or equal insulation).
37. Q. *How should power wires be connected to stationary electrical equipment?*
    A. By secure and permanent connections; hooked or wrapped connections should not be used.
38. Q. *What should be done to protect operators of electrical machinery against shock?*
    A. Machine frames should be grounded and insulating platforms or mats should be provided around stationary equipment.
39. Q. *What type of disconnects should be used with all electrical machinery?*
    A. Enclosed switches to protect the operator against arcs.
40. Q. *What should not be permitted to accumulate in the boxes enclosing contactors and switches?*
    A. Coal dust.
41. Q. *What type of fuse is prohibited as dangerous?*
    A. An open fuse.
42. Q. *How should trolley-pole cables be maintained to permit safe reversing?*
    A. They should be long enough and thoroughly insulated.
43. Q. *What type of nip should not be used?*
    A. A hooked nip.

44. Q. *What device should be provided on reel and double-pole locomotives to disconnect current from the unit not in use?*
A. Transfer switches.
45. Q. *What is the purpose of bonding rails?*
A. To provide a continuous return circuit of low resistance.
46. Q. *Where should bonds be placed?*
A. At every rail joint, with crossbonds at intervals of not more than 200 feet.
47. Q. *How can switches be bonded?*
A. By crossbonding.
48. Q. *What should be the minimum space provided for the passage of men near stationary electrical apparatus?*
A. 3 feet.
49. Q. *How should employees be protected from contact with electrical equipment and control- and switch-board installations?*
A. By adequate fencing or guarding and by heavy rubber mats or insulated platforms. (*See* fig. 61.)
50. Q. *What are the dangers connected with signal equipment and telephones?*
A. The danger of shock from contact with circuits of higher voltage and ignition of gas by sparks from improper equipment.
51. Q. *How may telephone circuits be protected from the hazards of contact with high-voltage lines?*
A. By proper fusing and provision of telephone lightning arresters.
52. Q. *Where should bare telephone wires be installed?*
A. On the opposite side from power wires.
53. Q. *How should telephone wires installed near power lines be protected?*
A. By proper insulation.

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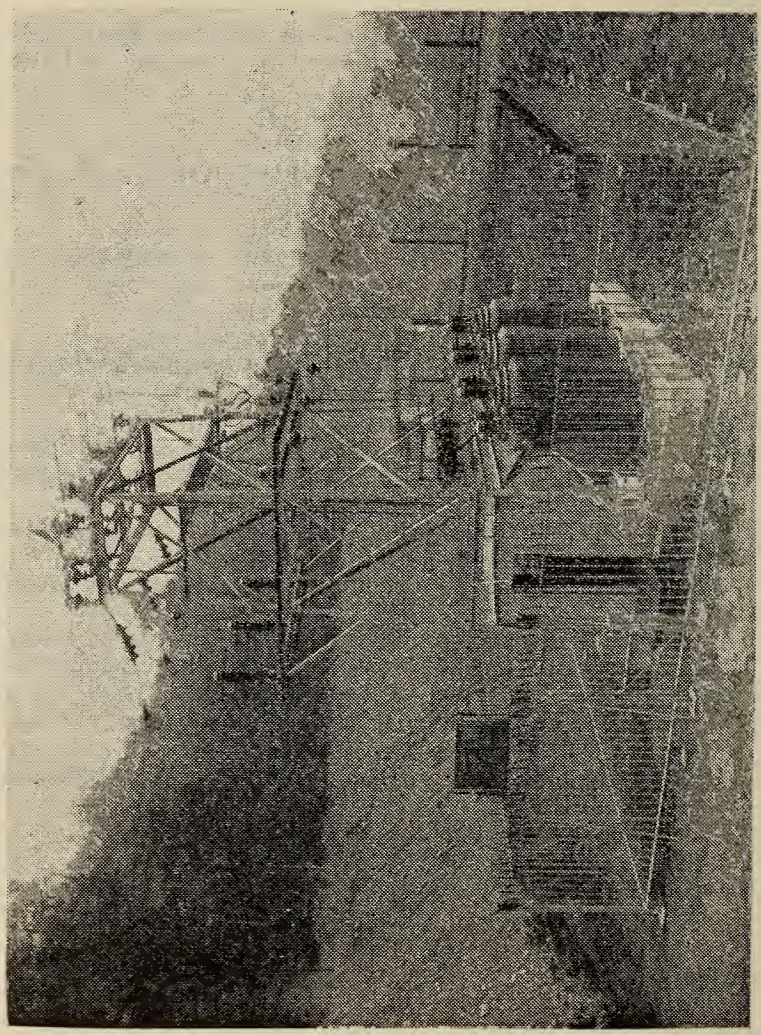

FIGURE 61.—High-tension lines and equipment should be fenced in effectively or otherwise made inaccessible to unauthorized persons.

54. Q. *How should telephone wires be installed when they cross power wires?*
    A. They should be insulated and installed in conduit.
55. Q. *What protection should be provided for telephone wires at the entrance to the mine?*
    A. Protection against high voltage and lightning.
56. Q. *What should be the maximum distance of telephones from working faces?*
    A. 3,000 feet.
57. Q. *What protection should be afforded lighting circuits underground?*
    A. Lighting circuits should be properly insulated, provided with switches, and properly fused.
58. Q. *How should lighting circuits be connected to trolley or feeder circuits?*
    A. They should be fastened securely to the trolley or feeder circuit by a positive clamp; they should never be wrapped or tied about the stem or stud of trolley hangers.
59. Q. *How should the ground connection for lighting circuits taken off the trolley or feeder circuit be made?*
    A. The ground connection should be welded or clamped securely to the rail bonding.
60. Q. *How should incandescent lamps be placed?*
    A. They should be placed so that they cannot come in contact with combustible material.
61. Q. *Where should incandescent lights* **not** *be used?*
    A. Incandescent lights, unless of the portable permissible storage-battery type, should not be used beyond the last crosscut or in any return airway.
62. Q. *How should underground electrical equipment be grounded?*
    A. By connection to a special ground plate or to well-bonded track or water lines.

63. Q. *How can a special ground plate be prepared?*
A. By embedding a plate in moist ground or in a mixture of charcoal and salt.
64. Q. *To what type of equipment should grounding* not *be made?*
A. To unbonded conveyor units or unbonded track.
65. Q. *What portable electrical equipment should be grounded?*
A. Frames of drills or other electrical tools intended to be held in the hands while being operated should be grounded.
66. Q. *How can a motor be protected against overload?*
A. By fuses or by overload relays.
67. Q. *How can a motor be protected from undervoltage?*
A. By undervoltage release coils.
68. Q. *How can the danger of fire from an operating motor be lessened?*
A. By protective devices, workmanlike installation, and clean and incombustible surroundings.
69. Q. *What is a common cause of arcing in a motor?*
A. Poor connections and dirty or defective parts.
70. Q. *How should underground electric stations be constructed?*
A. They should be in rooms of fireproof construction and should be provided with fireproof doors that will close automatically in case of fire. (*See* fig. 62.)
71. Q. *What fire-fighting material should be provided at underground electric stations?*
A. Clean, dry, sand or rock dust or suitable-type fire extinguishers placed outside the station where they will be readily available. (*See* fig. 63.)
72. Q. *How should man trips be protected against electric shock hazard?*
A. The trolley wire should be guarded the full length of the man trip at all man-trip loading zones.
73. Q. *What additional protection should be afforded man trips against the electric shock hazard?*

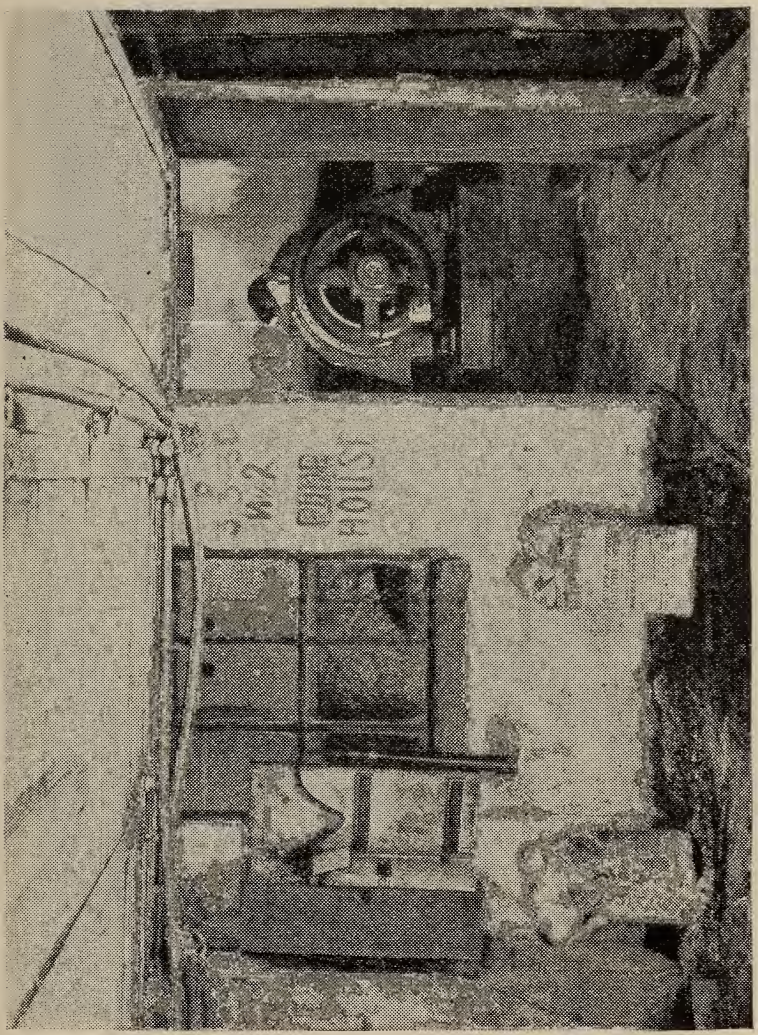

FIGURE 62.—Underground substations should be of fireproof construction, with wiring properly installed on insulators and frames of all equipment effectively grounded.

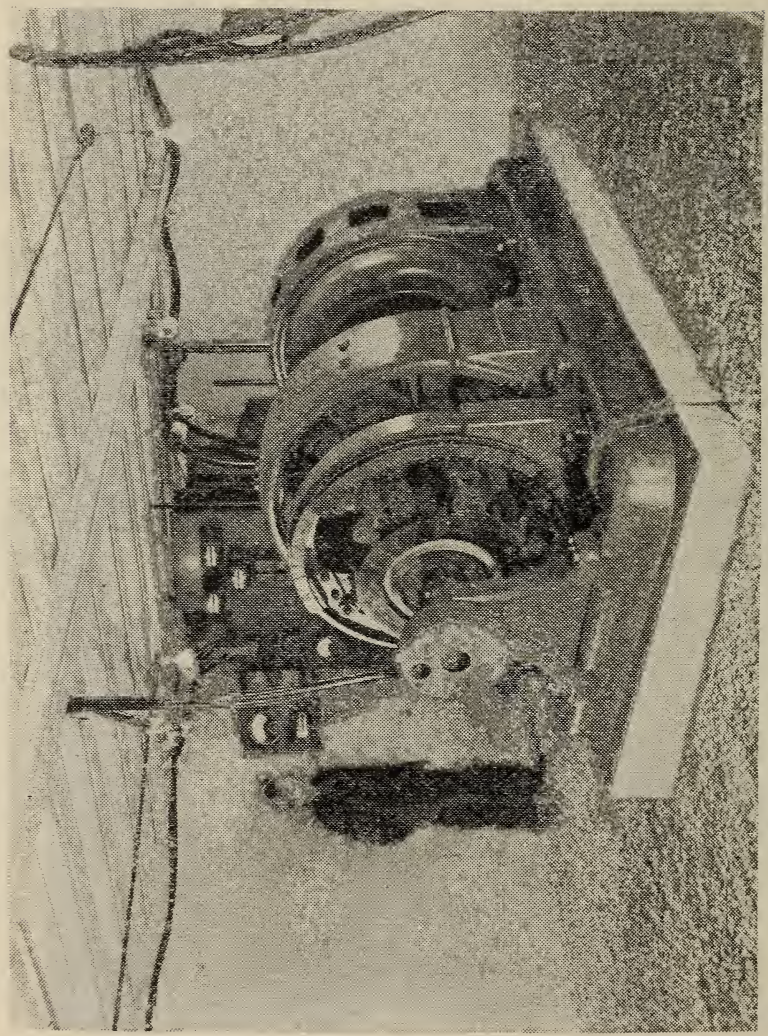

FIGURE 63.—Fire extinguishers and rock dust should be kept at every underground electric station.

A. The power should be cut off from the trolley circuit while the man trip is loading and unloading, and men should ride on the side opposite the trolley wire.

74. Q. *Who should be familiar with the location of all cut-out switches on trolley and feeder lines?*

A. All officials, haulage crews, electricians, machine operators, pumpers, and others connected with the use and maintenance of electrical equipment.

75. Q. *What can every mine worker do to reduce the hazards from electricity?*

A. *He should call the attention of the mine foreman to any* defects noted in the electrical equipment and transmission lines.

76. Q. *What special training should be given to all mine employees who have occasion to work with electrical equipment?*

A. They should be trained in the application of artificial respiration.

77. Q. *What instructions should be posted at every electric station and at the entrance to the mine?*

A. Instructions in artificial respiration.

NOTE.—Information relative to electricity in connection with the explosion and fire hazard is contained in the section, Prevention of Gas and Dust Explosions and Mine Fires, under Sources of Ignition, p. 122.

PREVENTION OF ACCIDENTS FROM MACHINERY AND TOOLS

TYPICAL EXAMPLES OF MACHINE AND TOOL ACCIDENTS

1. While a loader was loading coal his shovel probably was struck by a falling rock, or it may have struck the safety post while he was shoveling. The handle of the shovel struck him in the abdomen, rupturing the bowels and causing his death 6 days later.

This fatality could have been avoided if the loader had been more careful.

2. A tippleman was greasing the bearings of the lump-coal loading boom at the bottom of the shaker screens when his loose coat became caught in the conveyor chain, and he was dragged between the conveyor and the screen. He died 1 hour later.

Loose clothing should not be worn by men working around machinery (see fig. 65). Clothing should fit snugly and be kept tight against the body.

3. A machineman was cutting a face when the cutter chain struck a hard sulfur rock. The machine kicked back, crushing the machineman between the machine and the rib and killing him instantly.

The report does not state whether or not the machine was sumping in high speed, but in any event the cutter or his helper should not stay directly back of the machine while it is in operation.

4. A motorman had placed a car loaded with timbers near the boom of a loading machine. After he had helped unload the timbers he started to walk past the boom toward the face on the side of the machine opposite from the machine operator. The machine operator started to move the machine into a loading position, and the boom swung around and crushed the motorman against the rib, killing him instantly.

A machine should never be started until the machine operator knows that all persons in the vicinity of the machine are in the clear.

5. A machineman had unloaded a cutting machine and had started to sump up when the jack pipe slipped out of the roof and struck him as he was standing by the controller. He died 2 months later as a result of this accident.

The jack pipe may not have been set securely. Jack pipes are dangerous and have caused many accidents. Extreme care must therefore be exercised in using them.

QUESTIONS AND ANSWERS

1. Q. *How many underground coal miners were killed by machinery (other than locomotives and cars) in 2 recent typical years?*
   A. 38 in 1939 and 28 in 1940.
2. Q. *What percentage of the total number of underground coal miners killed in 1939 and 1940 was killed by machinery?*
   A. Almost 4 percent in 1939 and slightly more than 2 percent in 1940.
3. Q. *Should combustible motor fuels that generate dangerous gas or fumes be used underground?*
   A. No.
4. Q. *What haulage power other than petroleum or hydrocarbon compounds is prohibited from use in a producing mine?*
   A. Steam.
5. Q. *What is the principal hazard connected with grinding or pouring hot metal?*
   A. Serious injury may be caused to the eyes. (*See* fig. 64.)
6. Q. *What protection should be provided for men exposed to drowning at river loading points?*
   A. Life belts.
7. Q. *What is the danger in wearing loose clothing?*
   A. It may be caught in moving machinery. (*See* fig. 65.)
8. Q. *What is the most common cause of serious injuries to persons working with portable machinery?*
   A. Getting on or off in front of equipment when it is in motion.
9. Q. *What is the duty of cutting-machine men relative to others in the vicinity while the machine is in operation?*
   A. They should not permit other persons to remain near the machine.

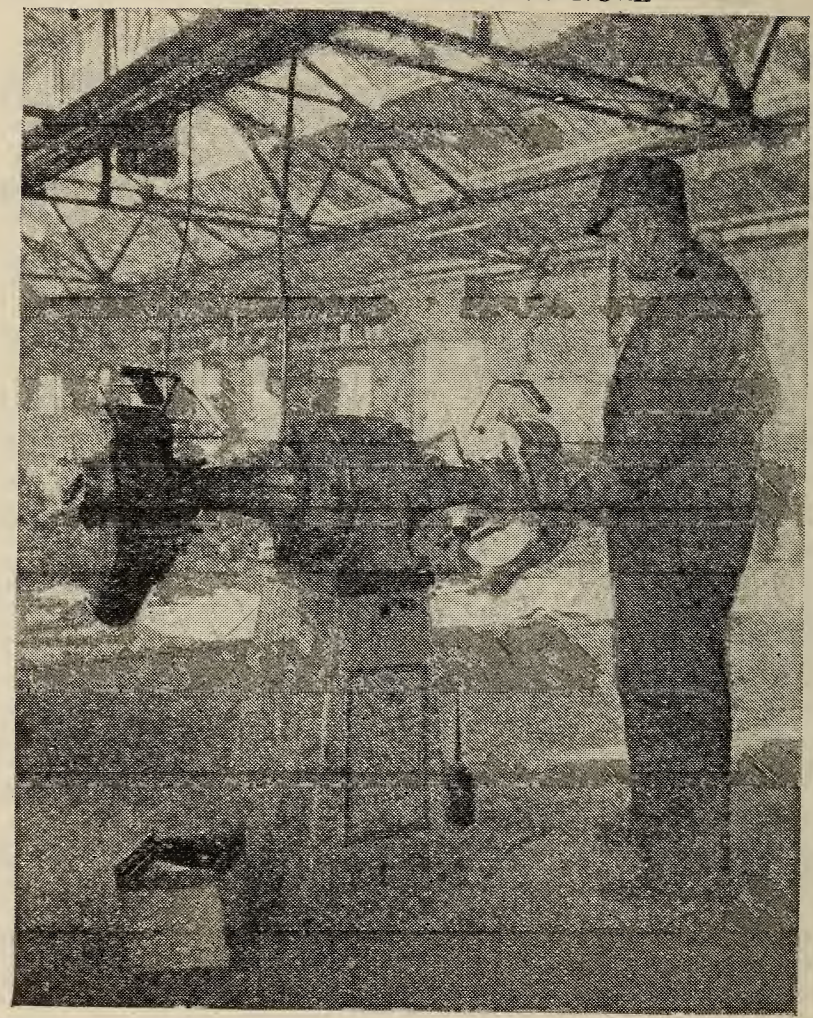

FIGURE 64.—Grinding wheels should be enclosed as completely as possible, and glass shields or goggles used to safeguard the eyes.

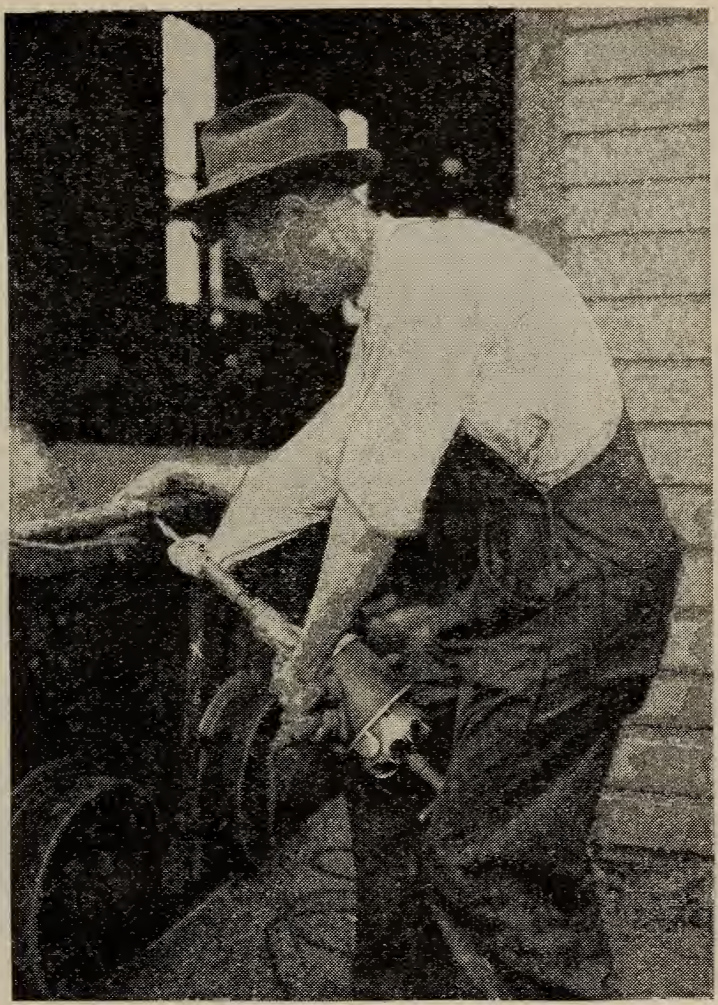

FIGURE 65.—Loose clothing worn near moving machinery is always a hazard.

10. Q. *When should the cutting machine not be moved?*
    A. When the cutter chain is in motion.
11. Q. *What protective devices should be provided for cutter chains and the arms and chains of loading heads when not in use?*
    A. Visible locking devices.
12. Q. *How should the front ends of cutter bars be guarded while tramming?*
    A. By removing or guarding the bits.
13. Q. *Why should those unfamiliar with a piece of equipment be prohibited from operating it?*
    A. Unfamiliarity may result in injury.
14. Q. *What protective devices should be used on gears, belts, and revolving parts of stationary machinery?*
    A. Guards. (*See* fig. 66.)
15. Q. *What precaution should be observed when reassembling a machine with dangerous contacts or moving parts?*
    A. All guards or safety devices should be replaced.
16. Q. *What precaution should be taken before starting machinery where two or more persons work?*
    A. Signals should be given and answered.
17. Q. *What precaution should be taken with machinery and equipment raised for repairs?*
    A. They should be blocked securely.
18. Q. *Why should repairs, adjustments, or oiling of moving machinery be prohibited?*
    A. Limbs or clothing may become entangled.
19. Q. *What should* not *be permitted to accumulate on machinery?*
    A. Oil, grease, and dust.
20. Q. *How should transmission belts in motion be shifted?*
    A. By a shifting device only.
21. Q. *What should be done with defective machinery or equipment?*
    A. It should be taken from service until repaired.

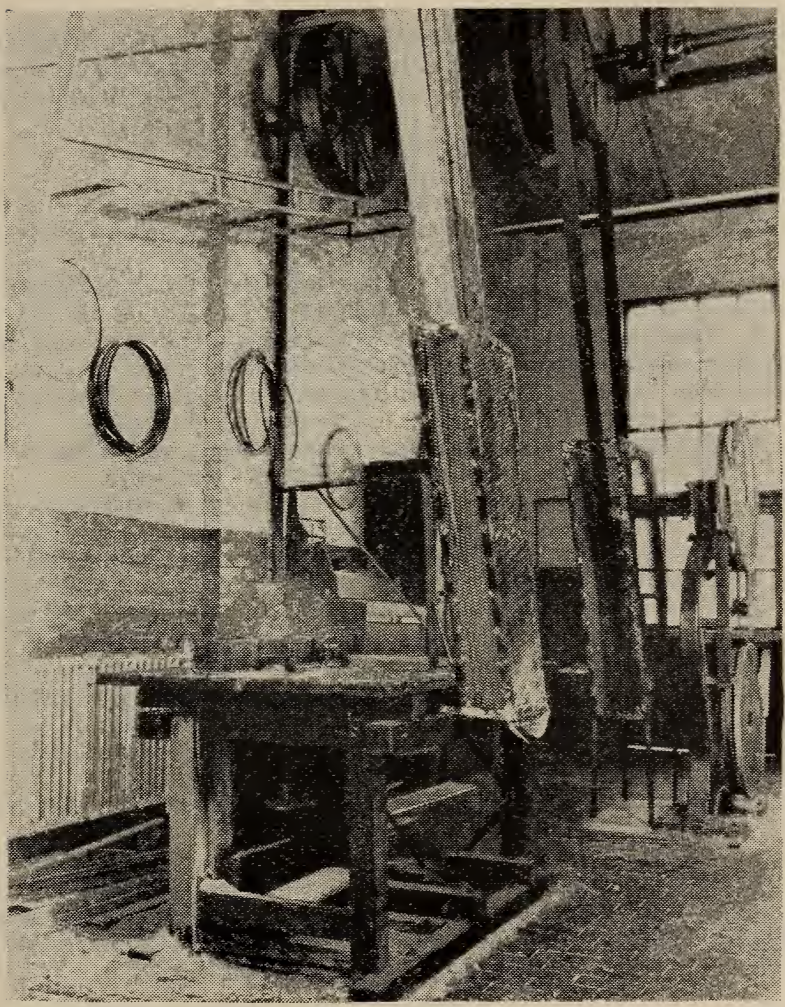

FIGURE 66.—Transmission belts and moving parts of machinery should be guarded effectively.

22. Q. *What precaution should be taken when pipe is heated?*
A. To see that it is open throughout its length, as any closing may trap water, which may burst the pipe when heated.
23. Q. *How should wire ropes be maintained?*
A. In safe operating condition.
24. Q. *What makes wire rope unsafe?*
A. It gradually deteriorates with constant wear until it will break under load.
25. Q. *What signs of deterioration are likely to be present in a worn or defective rope?*
A. Appreciable decrease in the diameter of the rope and the appearance of broken strands.
26. Q. *How should rollers on inclines and rope haulage be maintained?*
A. By keeping the bearings greased and replacing worn rollers.
27. Q. *What danger exists when an employee is equipped with defective or improper tools?*
A. Flying burrs or uncontrolled action may cause serious injury.
28. Q. *Who should be responsible for the condition of hand tools?*
A. The user should be responsible for the condition of his own tools, and the foreman should be responsible for the condition of company-owned tools.
29. Q. *In what condition should hand tools be maintained?*
A. With good operating faces and handles.
30. Q. *What is the most dangerous tool in the hands of a miner?*
A. The ax.
31. Q. *How can the use of an ax by miners be limited?*
A. By providing them with prepared cap pieces and wedges.
32. Q. *What should be the maximum length of an ax handle?*
A. It should not exceed 18 inches.

33. Q. *What tool should be used in taking down rock or slate?*
A. A slate bar of adequate length.
34. Q. *Why is it unsafe to use a pick to take down loose slate or rock?*
A. The use of a pick requires a miner to stand close to the rock that he is taking down; when it falls, it may injure his feet or legs.
35. Q. *What protective devices should be provided for openings in floors or ground?*
A. Guards.
36. Q. *What precaution should be taken while portable machines are being trammed from one place to another?*
A. The machine helper should walk ahead of the machine to see that the road is clear and to warn anyone who may be endangered.
37. Q. *What provision should be made for tramming machines along the haulage road where trolley wire has been installed?*
A. The machines should be equipped with trolley poles. Nipping is an unsafe practice.
38. Q. *How can injury to persons by mining and loading machines be avoided?*
A. Operators should be careful when starting and stopping machines.
39. Q. *What precautions should be taken in setting a jackpipe?*
A. A jackpipe should be long enough and should be anchored securely in the roof and inclined slightly in line with the rope or chain so that it will not pull out. The rope or chain should be tightened by hand.
40. Q. *What causes a mining machine sometimes to jump back out of the cut?*
A. The cutter chain strikes a hard substance, such as a sulfur ball, and the action of the revolving chain pushes the machine violently back out of the cut.

41. Q. *When is the machine most likely to jump back out of the cut?*
    A. When it is sumping on high speed.
42. Q. *Can a machine jump back out of the cut while sumping at low speed?*
    A. Yes; this has been known to happen.
43. Q. *How can injuries caused by the machine jumping back from under the cut be avoided?*
    A. The machine operator and his helper can avoid injury by keeping away from the back end of the machine and the vicinity of the cutter bar while sumping.
44. Q. *What is the principal danger in connection with the use of lifting jacks?*
    A. The machine slips off the jack and falls upon a workman.
45. Q. *How can this hazard be avoided?*
    A. By properly blocking up the machine after it has been raised by the lifting jack.
46. Q. *Why should the lifting-jack handle or lever be removed after the machine has been raised?*
    A. The projecting handle is dangerous and may strike someone if the machine suddenly slips off the jack.
47. Q. *What danger is there in connection with the revolving cutter-chain bits?*
    A. A workman may get caught by the bits and severely lacerated, or he may get dragged under the cut.
48. Q. *How can the danger from revolving cutter-chain bits be avoided?*
    A. By keeping away from the cutter chain while it is in motion.
49. Q. *How can injuries to the hands, while handling mining-machine feed and tail ropes, be avoided?*
    A. By keeping the ropes in good condition and by wearing suitable gloves.

50. Q. *How can injuries to persons, other than those engaged in operating machines, be avoided?*
    A. By keeping all persons other than those operating the machines at a safe distance while the machines are in operation.
51. Q. *Is it considered a safe practice to operate two different machines, for example, a cutting machine and an electric drill, in a working place at the same time?*
    A. No; this is a dangerous practice and should not be permitted.
52. Q. *What is the principal danger in operating hand-held or post power drills?*
    A. A workman's clothing may get caught on protruding parts of the chuck or drill shaft.
53. Q. *How can this danger be avoided?*
    A. By employing a drill so designed that there are no projecting lugs, bolts, or other projections on the shaft chuck or auger, and by the workmen wearing clothing that fits snugly.
54. Q. *What is the safest way of handling excess trailing cable in conjunction with portable machines?*
    A. Excess cable should be kept reeled up on reels attached to the machines.

FIRST AID TO THE INJURED

ARTIFICIAL RESPIRATION

1. Q. *What is the first fundamental of first aid?*
   A. Artificial respiration.
2. Q. *What is artificial respiration?*
   A. A method by which normal respiration is imitated by manual movements to restore breathing.
3. Q. *What are some of the conditions in which artificial respiration is required?*

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A. Electric shock, gas poisoning, drowning, and suffocation from various causes.

4. Q. *When artificial respiration is necessary, how soon should it be begun?*
   A. It should be begun at once if the patient is at a point free from danger; otherwise, as soon as the patient has been moved to a safe place. (*See* fig. 67.)
5. Q. *How long should artificial respiration be continued?*
   A. Until natural breathing has been restored or until a physician pronounces the patient dead.
6. Q. *How should the patient be prepared for artificial respiration?*
   A. All foreign bodies should be removed from the mouth; the tongue should be pulled forward; and tight clothing at the neck, chest, and waist should be loosened.
7. Q. *Should treatment for physical shock be given during artificial respiration?*
   A. Treatment for physical shock should be given throughout artificial respiration.
8. Q. *What stimulant should be given during artificial respiration, and by what means?*
   A. Aromatic spirits of ammonia should be given by inhalation.
9. Q. *What two methods of artificial respiration are used in first aid?*
   A. The Schaefer or prone-pressure method and the Sylvester method.
10. Q. *Which of the two methods of artificial respiration is preferable, and why?*
    A. The Schaefer method of artificial respiration is preferable because it is simpler and easier to perform.
11. Q. *Describe the position of the patient in the Schaefer method of artificial respiration.*
    A. In the Schaefer method of artificial respiration, the patient is laid face down, one arm extended directly

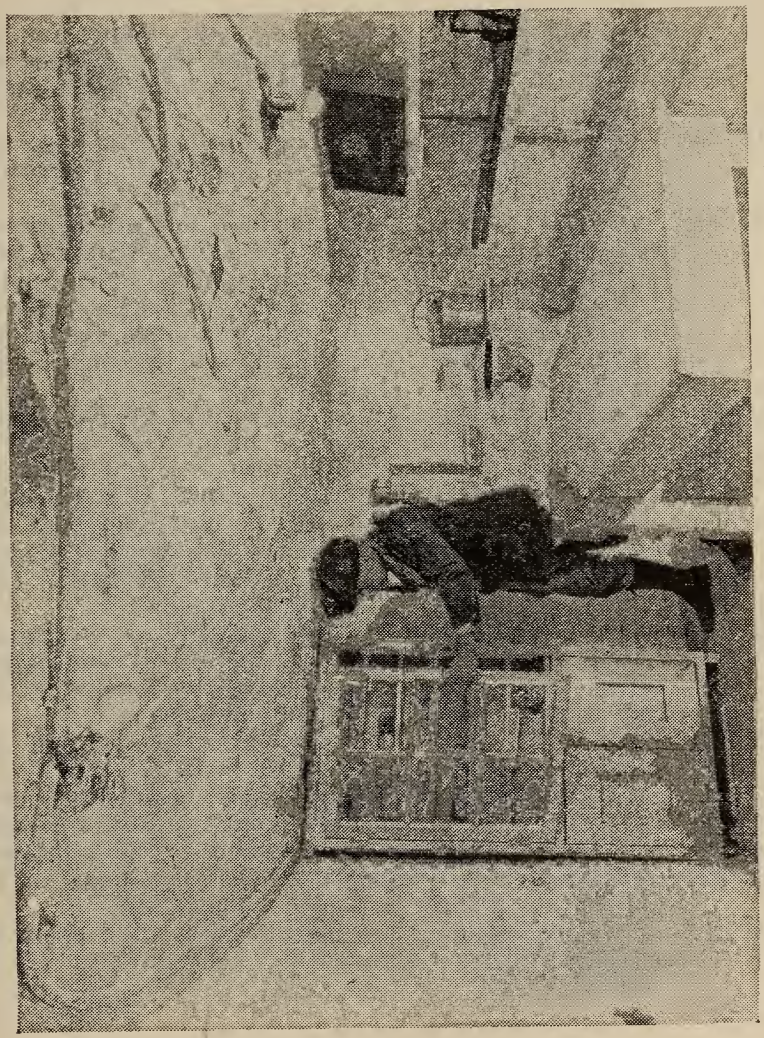

FIGURE 67.—Clean, well-illuminated first-aid stations should be provided on every working section.

over his head, the other bent at the elbow, and the head turned toward the extended arm so that the side of the face will rest on the hand or forearm of the bent arm.

12. Q. *Describe the position of the operator at the beginning of the Schaefer method of artificial respiration.* (*See* fig. 68.)

A. The operator should kneel, straddling the patient's thighs, and his knees should be at such a distance from the hip bone as will allow the placing of the palms of the hands in the small of the patient's back with the fingers resting on the ribs, the little finger just touching the lowest floating rib, and the thumbs and fingers in a natural position.

13. Q. *Describe the compression or expiration stroke in the Schaefer method of artificial respiration.*

A. The compression or expiration stroke in the Schaefer method of artificial respiration is done with the arms held straight. Swing forward slowly so that the weight of the body is gradually brought to bear on the patient, keeping the elbows straight. (*See* fig. 69.)

14. Q. *Describe the position of the operator's arms in relation to the shoulder and heel of the hands at the completion of the compression or expiration stroke in the Schaefer method of artificial respiration.*

A. The shoulder should be directly over the heel of the hand at the end of the forward swing.

15. Q. *How long should the compression or expiration stroke in the Schaefer method of artificial respiration take?*

A. The complete compression stroke should take 2 seconds.

16. Q. *Describe the decompression or inspiration stroke in the Schaefer method of artificial respiration.*

A. It is made by swinging the body backward so as to remove the pressure completely. (*See* fig. 70.)

FIGURE 68.—Artificial respiration. 1. Straddle the patient's thighs, with your hands on his back and your little fingers near his short ribs.

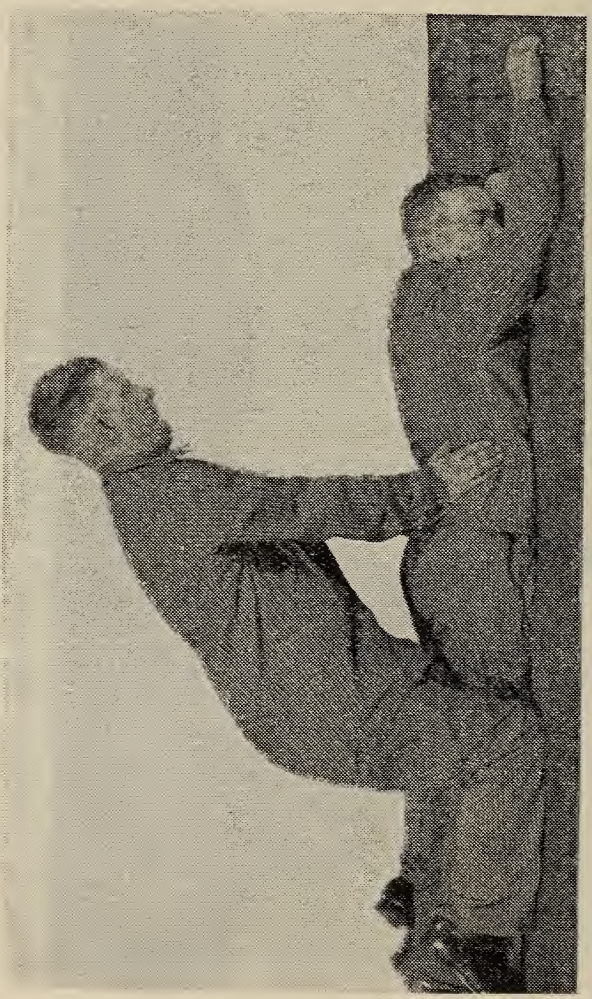

FIGURE 69.—Artificial respiration. 2. Now swing slowly forward, gradually transferring your weight to the patient. This will compress his lungs and force out air.

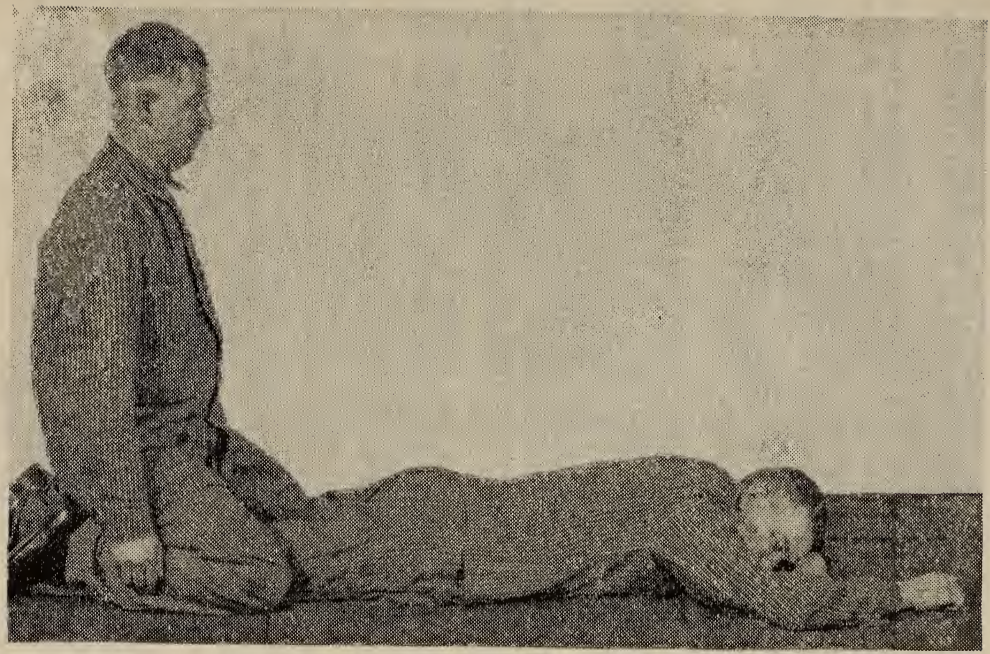

FIGURE 70.—Artificial respiration. 3. Next, swing back to a relaxed position, removing your hands from the patient as you do so. This will allow the patient's chest and lungs to expand, drawing in fresh air. The procedure should require 4 seconds and should be repeated at the rate of 15 times a minute until the patient revives.

17. Q. *How long should the decompression or inspiration stroke take in the Schaefer method of artificial respiration?*
    A. It should consume 2 seconds.
18. Q. *How long should the combined expiration and inspiration strokes take, and how many times per minute should the double stroke be given?*
    A. The entire compression-expiration and decompression-inspiration stroke should be completed in 4 seconds, thus permitting 15 double strokes per minute.
19. Q. *What care is necessary after the patient has been revived?*
    A. He should be kept lying down, wrapped in a blanket, and given some stimulant, such as aromatic spirits of ammonia (1 teaspoon in one-half glass of water) or hot drinks of coffee or tea.
20. Q. *What are the symptoms of electric shock?*
    A. Sudden loss of consciousness, absent or very slight respiration, absent or very weak pulse, and probable burns.
21. Q. *When a person who has received an electric shock is still in contact with the electric conductor, what should be done first?*
    A. He must be rescued from contact immediately.
22. Q. *Name some of the means by which a person may be removed from contact with an electric conductor.*
    A. Cutting off the current at a switch; short-circuiting or grounding the current; dragging or prying the person from contact; dragging or prying the conductor from the patient; cutting the conductor.
23. Q. *What precautions should be taken by the person removing another from electric contact?*
    A. He should always be absolutely sure he is properly insulated from the electric current by standing on a dry surface or by using a dry belt, handkerchief, or piece of dry clothing to pull the victim away from contact with the circuit.

24. Q. *How may gas poisoning be prevented?*
    A. The chief factors in preventing poisoning by gases are good ventilation, avoidance as far as possible of air known to contain poisonous gases, and the use of adequate protective equipment in atmospheres known to contain poisonous gases.
25. Q. *Describe the general care of a patient suffering from gas poisoning.*
    A. Rescue the patient, and remove him to fresh air as quickly as possible. Procure medical aid; if breathing has stopped or is weak or intermittent, begin artificial respiration promptly.
26. Q. *How should a drowning person be handled?*
    A. He should be removed from the water at once. Water in his air passages and stomach should be removed by raising him several times with the hands locked under his stomach, and artificial respiration should be begun.
27. Q. *How should a suffocated or asphyxiated person be handled?*
    A. He should be removed immediately to fresh air. If some object is blocking his windpipe, it should be removed and artificial respiration begun.

CONTROL OF BLEEDING

28. Q. *What is the second fundamental of first aid?*
    A. The second fundamental in first aid is the control of bleeding.
29. Q. *What is hemorrhage or bleeding?*
    A. A flow of blood from an artery, vein, or capillary.
30. Q. *What are the symptoms of bleeding from an artery?*
    A. The blood spurts intermittently and is bright red.
31. Q. *What are the symptoms of bleeding from a vein?*
    A. Bleeding is a steady flow, and the blood is darker red.

32. Q. *What are the symptoms of capillary bleeding*[
A. The blood just oozes from the wound.
33. Q. *If blood is spurting from a wound or flowing in a steady stream, what should be done and why?*
A. It should be checked as soon as possible or the patient may lose enough blood to cause shock or endanger life.
34. Q. *What amount of blood lost by an adult is likely to prove fatal?*
A. The loss of 2 to 3 pints of blood may prove fatal.
35. Q. *How may the flow of blood be stopped from a wound with venous bleeding?*
A. Bleeding from a vein usually can be checked by applying a sterile bandage compress directly over the wound. If this fails, a constriction should be applied on the side of the wound away from the heart.
36. Q. *How would you stop the flow of blood where capillaries are cut?*
A. By sterile bandage compress applied directly over the wound.
37. Q. *What is meant by a pressure point, and how many are there on the human body?*
A. A point where an artery comes close enough to the surface of the skin to be reached; its proximity to a bony structure allows pressure on the artery against the bone. There are 22 pressure points on the human body, 11 on each side. (*See* figs 71, 72, and 73.)
38. Q. *Describe digital pressure.*
A. Digital pressure is that exerted by the finger or thumb against an artery at a pressure point.
39. Q. *What is a tourniquet?*
A. An appliance used to check severe bleeding from an artery at a pressure point.

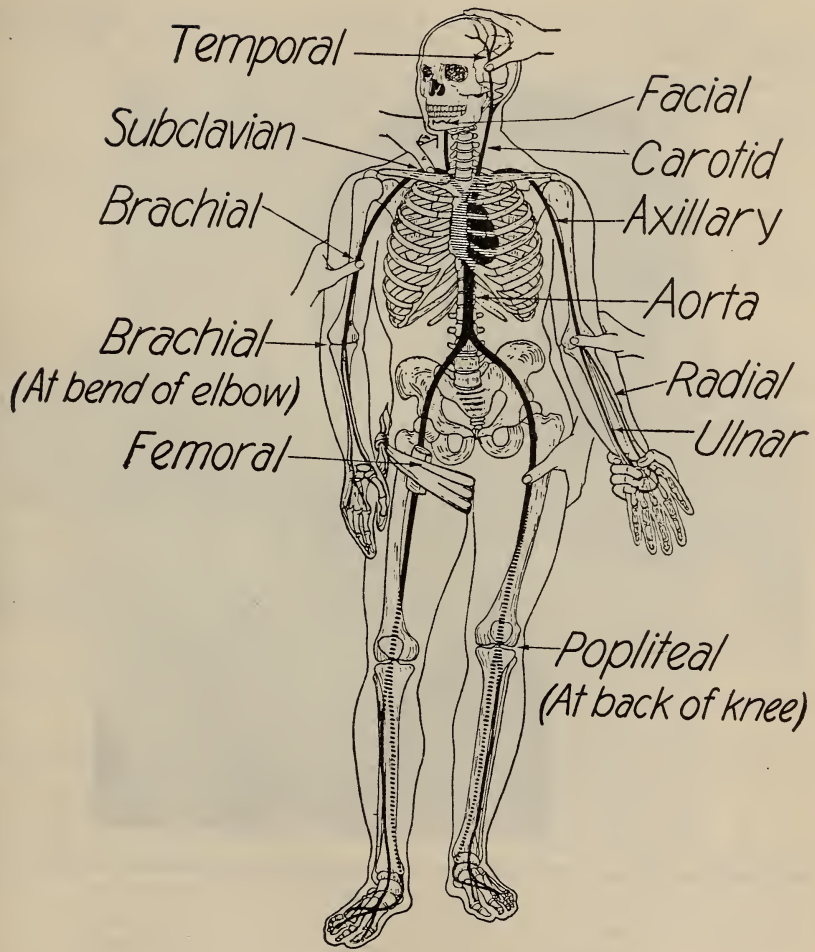

FIGURE 71.—Arteries and pressure points.

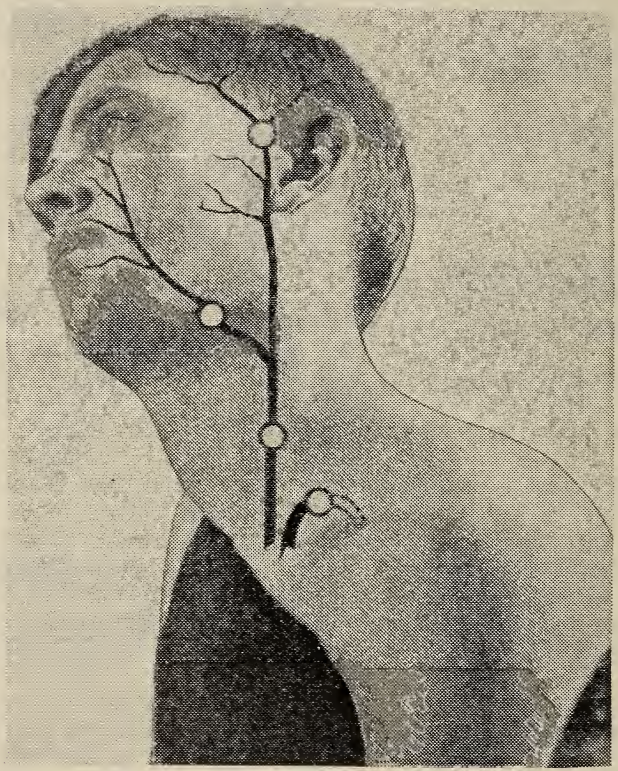

FIGURE 72.—Course of arteries and pressure points marked on surface of head and neck.

40. Q. *What types of tourniquets are used in first aid?*
    A. The standard type (usually a piece of web belting about 36 inches long, with a buckle or snap device to hold it tight when applied) and improvised tourniquets of suitable material to hold a hard object against the pressure point.
41. Q. *What precautions should be taken with a hard object used with a tourniquet?*
    A. It should be well wrapped or padded with cloth in order not to bruise the skin and the walls of the artery.

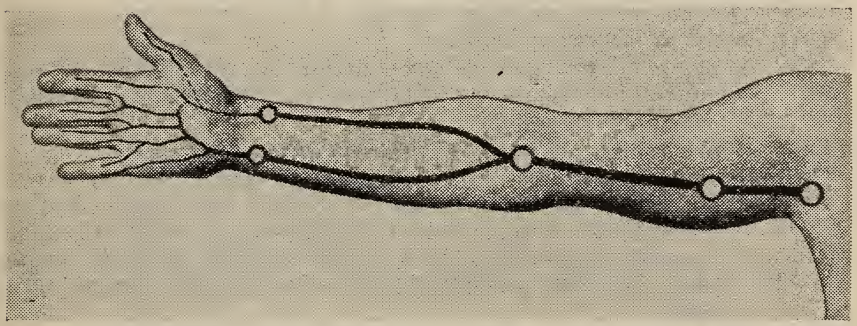

FIGURE 73.—Course of arteries and pressure points marked on surface of upper extremity.

42. Q. *How long should a tourniquet be allowed to remain tight?*
    A. Not longer than 10 minutes.
43. Q. *At the expiration of 10 minutes, what should be done?*
    A. The tourniquet should be loosened for a few seconds or until normal color returns to the part below the tourniquet; if bleeding persists, it should be tightened again for another interval of 10 minutes.

44. Q. *What is the duty of a first-aid man when he turns a patient with a tourniquet in place over to someone else?*
    A. When a patient with a tourniquet or venous-control constriction in place is turned over to someone else, the first-aid man must inform whoever receives the patient that a tourniquet or constriction has been applied and, if tight, how long it has been tight.

PHYSICAL SHOCK

45. Q. *What is the third fundamental of first aid?*
    A. Treatment of physical shock.
46. Q. *What is physical shock?*
    A. A state of collapse or prostration in which the normal action of the heart, the respiration, and the circulation are impeded.
47. Q. *What are the causes of physical shock?*
    A. Severe or extensive injuries, severe pain, loss of blood, surgical operations, severe burns, accidents due to electricity or gas, certain illnesses, poisons taken internally, exposure to extremes of heat or cold, seeing own injuries or injuries of others, fright, anger, and joy.
48. Q. *Does physical shock occur after every injury?*
    A. Physical shock occurs to some degree after every injury. It may be so slight as not to be noticed.
49. Q. *How soon after the symptoms of physical shock are noticed should it be treated?*
    A. Physical shock should be treated immediately after the first evidence of its presence.
50. Q. *What are the symptoms of physical shock?*
    A. Face is pale with an anxious or dull expression. The eyelids, if open, droop; the pupils are large, and the eyes are dull. The patient may be partly or totally unconscious. The skin is cold and covered with a

clammy sweat. The patient feels cold and may have a chill. The pulse is weak and rapid if it can be be felt. The breathing is shallow and may be irregular. The patient is stupid and takes little interest in things about him. He may answer questions slowly or apparently fail to understand. He may be nauseated and vomit.

51. Q. *What is the treatment for physical shock?*
A. Place the patient in a comfortable position lying down, with his head on a level with his body; if there is a moderate slope to the ground where the patient is lying, place the head toward the down grade. If the patient is on a stretcher or body splint, elevate the feet end of the stretcher or body splint at least 6 inches. Remove all foreign bodies from the mouth, and cleanse the mouth of mucus or phlegm. See that the tongue is forward and not back over the windpipe. Loosen tight clothing from waist and neck. If the patient is nauseated and vomits, turn his head to one side so that the vomited matter will flow from the mouth and not choke him. Allow the patient to have plenty of fresh air. Wrap him in blankets or other suitable covering. Care should be taken that the material placed around him does not contaminate open wounds. Maintain heat under covering by applying heated objects. Give stimulants, by inhalation if the patient is unconscious or by mouth if he is conscious. Rub uninjured extremities toward the heart. Oxygen should be administered if available.

52. Q. *How should stimulants be given to an unconscious person in physical shock?*
A. Give nothing by mouth, as the patient may not swallow it, and the substance may pass into his windpipe and choke him. Aromatic spirits of ammonia should

be administered by pouring some on a piece of gauze or cloth and holding it under the nose for 30 to 40 seconds. The aromatic spirits should be tested before the patient is allowed to inhale it.

53. Q. *Under what conditions where physical shock is present should the head be raised?*
A. Fracture of the skull, unchecked severe bleeding from the head, sunstroke, and apoplexy.

54. Q. *Under what condition where physical shock is present should the patient* **not** *be wrapped in blankets or heated objects be applied?*
A. In sunstroke.

55. Q. *Under what conditions where physical shock is present should no stimulant be given?*
A. In case of severe bleeding, fracture of the skull, or sunstroke, stimulant should not be given.

WOUNDS AND BURNS

56. Q. *What is the fourth fundamental of first aid.*
A. The care of open wounds and burns.

57. Q. *What is an open wound?*
A. Any break in the skin. It may range from a pin puncture or scratch to an extensive cut, tear, or mash.

58. Q. *Describe the general care of open wounds.*
A. Check hemorrhage, and prevent any germs from entering wound by covering immediately with a sterile dressing.

59. Q. *Tell how the clothing should be removed to expose wounds.*
A. Rip or cut the clothing so that the injury may be seen.

60. Q. *What should be done where loose foreign particles are in or around an open wound?*
A. Loose, foreign particles in and around a wound may be wiped away with sterile gauze. Always wipe away from the wound and not toward it.

61. Q. *What should be done where foreign objects are embedded in an open wound?*
    A. Do not attempt to remove a foreign object embedded in a wound. Leave that to the doctor, as it may aid him in determining the extent of injury and involvement of deeper parts.
62. Q. *What only may touch an open wound?*
    A. A sterile bandage compress or sterile gauze placed over the wound and tied in place. Do not touch an open wound with your hand, clothing, or anything that is not sterile.
63. Q. *How large should sterile dressings be for an open wound?*
    A. Care should be taken to make all sterile dressings wide enough to cover the wound completely, as well as an area beyond each side of the wound.
64. Q. *How should bandages be applied in dressings for open wounds?*
    A. The bandage should be applied firmly but never too tightly. In bandaging the arms and legs, leave the tips of the fingers and toes uncovered wherever possible so that they may be seen, to permit easy examination and determine whether or not dressings are too tight.
65. Q. *Describe the general treatment for burns and scalds.*
    A. Expose the burned surface, and apply a dressing to exclude the air, relieve pain, and prevent infection.
66. Q. *How should all clothing be removed from a burned area?*
    A. By cutting or ripping; any cloth that adheres to the skin should be cut around and left in place.
67. Q. *Are burns and scalds subject to infection?*
    A. Yes; just as are open wounds.
68. Q. *Should blisters be opened?*
    A. Blisters should not be intentionally opened or broken.

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69. Q. *What precautions are necessary in dressing a burn or scald where burned or scalded surfaces may come in contact with each other?*
A. Adjacent burned surfaces should never be permitted to come in contact with each other. A burn dressing should be placed between such surfaces.
70. Q. *How should bandages be applied in dressing burns or scalds?*
A. They should always be applied loosely, but snugly enough to hold in place.

DISLOCATIONS AND FRACTURES

71. Q. *What is the fifth fundamental of first aid.*
A. The care of dislocations and fractures.
72. Q. *What is a dislocation?*
A. A dislocation is a slipping out of normal position of one or more bones forming a joint.
73. Q. *What other injuries usually accompany a dislocation?*
A. The ligaments holding the bones in proper position are stretched and sometimes torn.
74. Q. *What are the general symptoms of dislocations?*
A. Rigidity and loss of function. The parts forming the joint are held stiff and cannot be moved. There is deformity; that is, the parts assume an unnatural shape compared with the normal joint on the opposite side of the body. In dislocations of the extremities, they may be either shorter or longer than normal. Pain usually is severe in the region of the joint. Swelling is present about the joint.
75. Q. *What is the general treatment for dislocations?*
A. Applying dressings, and in some instances splints, so that the parts are immobilized in the line of deformity in which they are found.

76. Q. *What dislocations may a first-aid man attempt to reduce?*
    A. In first aid, dislocations of the lower jaw, fingers, and toes may be reduced.
77. Q. *What are the general symptoms of fractures?*
    A. Pain in the region of the fracture, loss of function (if the long bones are involved), deformity or irregularity of the part, and swelling, moderate or severe; in fractures of the extremities, the limbs usually are shortened.
78. Q. *What is the general treatment of fractures?*
    A. Place the part in a position as nearly normal as possible; and, while support is maintained, prepare and apply a splint to immobilize the part so that movement is impossible.
79. Q. *How does the treatment of a simple fracture differ from that of a compound fracture?*
    A. A simple fracture requires only immobilization by proper dressings, whereas a compound fracture requires that a tourniquet be applied, tightly if there is evidence of arterial bleeding, otherwise loosely. The wound must be dressed appropriately. When the splints are applied in a compound fracture, the padding must be so arranged that the tourniquet can be tightened or loosened and that no pressure is made over the wound or on protruding ends of bones. Shock may be present in either simple or compound fracture.

TRANSPORTATION OF THE INJURED

80. Q. *What is the sixth fundamental of first aid?*
    A. Transportation of the injured.
81. Q. *What precautions should be followed before an injured person is moved?*

A. Never move an injured person until a thorough examination has been made and his injuries protected by proper dressings.

82. Q. *In what position should a seriously injured person be transported?*

A. A seriously injured person should be moved only in a lying position. If means are not immediately at hand for proper transportation of an injured patient, continue your care of the patient to conserve his strength until adequate means of transportation are available.

83. Q. *What is the responsibility of a first-aid man in transporting an injured person?*

A. To see that the patient is transported in such a manner that further injury is prevented, that the severity of the original injuries is not increased, and that the patient is subjected to no unnecessary pain or discomfort.

84. Q. *What precautions always should be taken before a patient is loaded on a stretcher?*

A. A stretcher always should be tested by a weight equal to or greater than that of the patient before the injured person is placed on it.

85. Q. *In carrying a patient on a stretcher, why should the rear man be out of step with the other stretcher bearers?*

A. The rear man breaks step with the other stretcher bearers to prevent swinging of the stretcher and jarring of the patient.

86. Q. *On which side is it preferable to lift an injured patient when loading or unloading a stretcher?*

A. It is preferable to lift the patient on the uninjured or least injured side before placing him on or unloading him from a stretcher. There may be exceptions to this rule.